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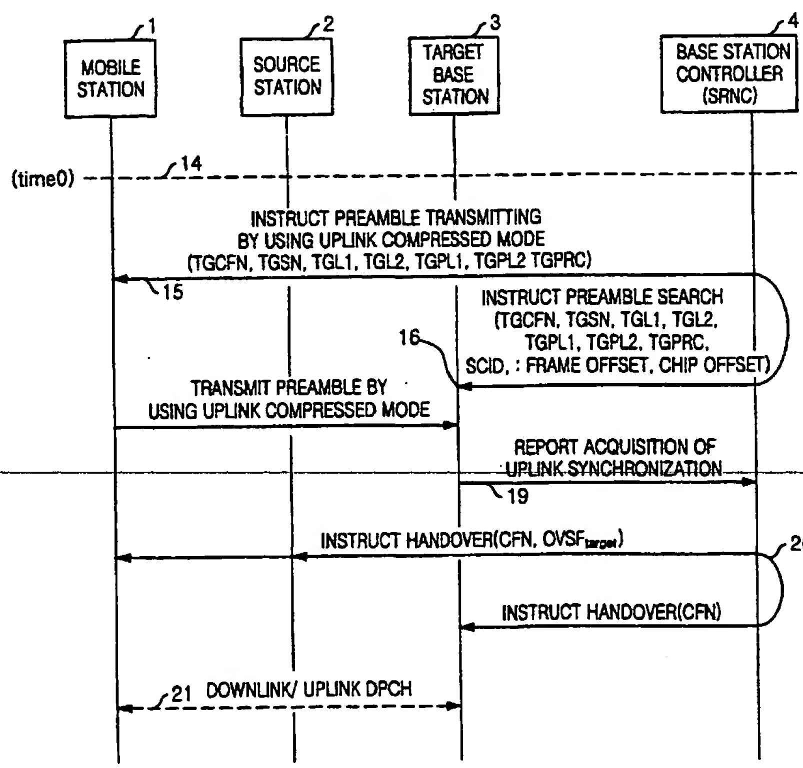
(54) Title: METHOD FOR SEAMLESS INTER-FREQUENCY HARD HANDOVER IN RADIO COMMUNICATION SYSTEM



(57) Abstract: A method for seamless inter-frequency hard handover in a radio communication system is disclosed. The method for seamless inter-frequency hard handover includes the steps of: a) at a mobile station, blocking a first uplink carrier frequency used for communication, transmitting a direct sequence spread preamable signal through a second uplink carrier frequency for a short time, and continuously performing the communication through the first uplink carrier frequency; and b) at a target base transciever station, acquiring an uplink synchronization of a mobile station based on the preamble before performing handover.

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METHOD FOR SEAMLESS INTER-FREQUENCY HARD HANDOVER IN RADIO COMMUNICATION SYSTEM

Technical Field

The present invention relates to a handover method in a radio communication system; and, more particularly, to a method capable of implementing a seamless inter-frequency hard handover in a direct sequence code division multiple access (DS-CDMA) system and a computer readable recording medium for executing the method.

Background Art

It is widely known that a soft handover, in which a frequency change does not occur, can be used generally for handover between base stations of one wireless communication service provider in a CDMA cellular system since all base stations of the one wireless communication service provider can use a same frequency for the soft handover.

The soft handover is a method for maintaining a communication link by simultaneously transceiving communication signal with both a source base station and a neighbor base station without changing a communication frequency when a mobile station is located at a cell boundary of the two base stations, i.e., when the mobile station moves from a coverage of the source base station to a coverage of the neighbor base station, and then disconnecting the communication link with the source base station, if a signal intensity of the source base station is weaken below a standard signal intensity as maintaining continuously the communication link with the neighbor base station. The above-mentioned soft handover provides the unstrained handover by eliminating an instant-disconnection, which is a chronic problem of an analog system, decreases a

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probability of call loss and maintains high quality communication.

However, the soft handover is not applicable in case a certain wireless communication service provider allocates different number of frequencies to the neighbor base stations according to a call density by considering an economy of a network design and an efficiency of investment, i.e., the neighbor base stations use different frequencies. That is, if the mobile station using a specific frequency of the source base station is moving to the cell of the neighbor base station, which does not equip the specific frequency, the soft handover cannot be applicable. Furthermore, the soft handover cannot be applicable between base stations possessed by two wireless communication providers using different frequencies although they adopt the same CDMA scheme. For these cases, the hardware handover has to be used.

The hard handover needs to be performed between frequencies in case of the handover from a wideband-CDMA (W-CDMA) time division duplex (TDD) to a W-CDMA frequency division duplex (FDD) or handover from global system for mobile communications (GSM) to the W-CDMA FDD.

Referring to Fig. 1, an example of the hard handover between a source base station 2 and a target base station 3 is explained as follows.

As shown in Fig. 1, the target base station 3 does not support communication frequencies f_1 and f_1' of a current mobile station 1.

In Fig. 1, in case of the mobile station 1 having a dual-mode receiver, the mobile station 1 can measure a signal intensity of a new frequency f_2 while demodulating downlink signals through the currently established frequency f_1 and acquire synchronization of signals transmitted from the target base station 3.

Such the dual-mode receiver needs an additional hardware for radio frequency (RF) compared to a single-mode

receiver and thus the complexity of a mobile device is increased.

To overcome above-mentioned problems, a compressed mode is defined in an asynchronous W-CDMA (FDD) standard (Release'99) of 3rd generation partnership project (3GPP), which was released at September 2000.

Fig. 2 illustrates an example of compressed mode transmission.

In the 3GPP standard, a frame has a length of 10 msec and consists of 15 slots.

For a transmission gap (TG) region 7 in a compressed frame, data transmission is not permitted. Instead of permitting the data transmission, a rate of frame errors of the compressed frame is maintained identical to that of a normal frame by keeping a transmitting power at a slot region 6 in the compressed frame higher than a power of the normal frame.

The mobile station 1 having the single-mode receiver can search the signal intensity of the new frequency f_2 in downlink on the handover situation shown in Fig. 1 by using the compressed mode of Fig. 2. That is, it is possible to search the signal intensity by dropping the current established communication frequency f_1, changing to a frequency f_2 and measuring the signal intensity of f_2 in the TG region and after the TG region is over, demodulating the call channel of the frequency f_1.

In the 3GPP (FDD) standard, the compressed mode is defined at not only the downlink but also the uplink. The downlink and uplink can be operated simultaneously as the compressed mode and only one of the downlink and the uplink can be operated as the compressed mode. A reason of defining the compressed mode in the uplink is for prevention of interference to the downlink when the mobile station 1 measures a frequency of the uplink and the downlink of a neighbor system such as 3GPP TDD or GSM. Therefore, even though the mobile station 1 employs the

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dual-mode receiver, the uplink needs to be operated as the compressed mode in case that the mobile station 1 measures the downlink of other system using a frequency similar to the frequency of the uplink.

In shortly, it is possible that the mobile station 1, which satisfies the 3GPP (FDD) standard, monitors a new frequency f_2 of the downlink before disconnecting the current established call channel completely in the handover situation in Fig. 1 and call disconnection of the downlink can be avoided although there occurs the hard handover to the new frequency f_2 since the synchronization of the downlink transmitted from the target base station 3 can be acquired by using a synchronization channel of f_2 and a common pilot channel.

On the other hand, in case of the uplink, since the target base station receives no signal before the mobile station 1 drops the current established frequency f_1' and transmits signals by using a new frequency f_2', i.e., the hard handover occurs, the synchronization of the uplink needs to be started at the target base station 3 from a moment that the hard handover occurs. There occurs call disconnection since at least one frame is required to acquire the synchronization of the uplink even if an outperformed searcher is used in the target base station 3.

Moreover, since, according to the 3GPP W-CDMA (FDD) scheme, corresponding base stations operate in asynchronization, the target base station 3 cannot detect a round trip delay between the mobile station 1 and the target base station 3 and therefore, a time for acquiring synchronization in the target base station 3 may be more than several frames since a search window size becomes very large, which a searcher has to search, in case that a coverage area of the base station is huge. In this case, several frame disconnection may be happened and current call disconnection also may be happened in more serious case. Also, in this case, a power may not be controlled

properly, so that a capacity of the uplink of the target base station 3 may be incredibly decreased.

In the 3 GPP W-CDMA standard (Release' 99), it is possible to perform the handover only in case a difference between a system frame number (SFN) of the target base station 3 and a connection frame number (CFN) of the mobile station 1 is known to the network. Therefore, the mobile station 1 needs to detect the SFN information of the target base station 3 by demodulating a common channel of the downlink of the target base station 3 before performing the handover and transmit the SFN information and a frame offset, which is the difference between the CFN of the mobile station 1, to the base station controller 4. Thereby allowing the base station controller 4 to decide an exact handover time, resulting in performing the handover. Above-mentioned operations are well performed in the soft handover between same frequencies. However, in case of the hard handover between different frequencies, the mobile station 1 should use the compressed mode of the downlink for acquiring the SFN information of the target base station 3.

However, in the standard (Release'99), it is impossible to acquire the SFN information by using the compressed mode since at least 50msec continuous demodulating time is required in the downlink for acquiring the SFN information. In case of the hard handover, since the mobile station 1 has to acquire the SFN information after being completely disconnected with the current established frequency and being connected to a new frequency, there may occur at least 50msec additional call disconnection.

The above-mentioned problems are not limited to the inter-frequency hard handover in the W-CDMA FDD and they may be happened when a multimode device having the dual-mode receiver or the single-mode receiver such as GSM/WCDMA FDD multimode device or W-CDMA TDD/W-CDMA FDD multimode

device performs the hard handover from the GSM system to the W-CDMA FDD system or from the W-CDMA TDD system to the W-CDMA FDD system.

As mentioned above, the disconnection is inevitable for performing the inter-frequency hard handover defined in the 3GPP W-CDMA FDD standard. Specially, in case of the mobile station having the single mode receiver, since the compressed mode is used in the downlink for searching signals of the target base station so the frame offset between the target base station and the mobile station is not known to the network. In this case, the disconnection problem becomes more serious since at least 50 msec disconnection is generated during performing the inter-frequency handover. This is indicated as a problem in the 3GPP. Therefore, a handover method, which performs the inter-frequency hard handover without disconnection, is required for addressing the problems in the asynchronous W-CDMA standard.

Disclosure of the Invention

It is, therefore, an object of the present invention to provide a method capable of implementing a seamless inter-frequency hard handover in a wireless communication system such as a DS-CDMA system and a computer readable recording medium storing instructions for executing the method.

In accordance with an aspect of the present invention, there is provided a method for a method for performing seamless inter-frequency hard handover in a radio communication system, including the steps of: a) a mobile station, disconnecting a first uplink carrier frequency used for communication, transmitting a direct sequence spread preamble signal through a second uplink carrier frequency for a short time, and continuously performing the communication through the first uplink carrier frequency;

b) a target base station, acquiring an uplink synchronization of the mobile station by using the direct sequence spread preamble; and c) performing the hard handover by using the uplink synchronization.

In accordance with another aspect of the present invention, there is also provided a method for a method for performing a seamless inter-frequency hard handover in a radio communication system in case that a base station controller (or a radio network) dose not know a frame offset, which is a difference between a connection frame number (CFN) of a mobile station and a system frame number (SFN) of a target base station, including the steps of: a) the mobile station, completely disconnecting a first uplink carrier frequency used for communication, transmitting a direct sequence spread preamble (or pilot) through a second uplink carrier frequency for a short time, and continuously performing the communication through the first uplink carrier frequency; b) the target base station, acquiring an uplink synchronization of the mobile station by using the preamble before performing the hard handover; c) the target base station, after acquiring the uplink synchronization, transmitting a direct sequence spread AI as a response for the acquisition of the uplink synchronization for a short time through a new downlink frequency; d) the mobile station, detecting the AI; e) the base station controller, calculating a frame offset by using the SFN, which is used for transmitting the AI and the CFN, which is used for receiving the AI, and transmitting the calculated frame offset to the target base station; and f) the base station controller, instructing the mobile station and the target base station to perform the handover.

The present invention transmits a preamble (or a pilot) through new frequency f_2' in a transmission gap (TG) by using an uplink compressed mode before a mobile station completely disconnects a currently established communication in an inter-frequency hard handover situation

described in Fig. 1.

The present invention provides a method for seamless inter-frequency hard handover by acquainting a synchronization of an uplink by using a preamble (or pilot) transmitted from a target base station before a currently established communication is completely disconnected.

In the present invention, the target base station transmits an acquisition indicator (AI) through downlink for a fast response of acquisition of the preamble (or pilot) transmitted from a mobile station in the transmission gap (TG).

The present invention also prevents an additional call disconnection in case a base station controller dose not know a frame offset, which is a difference between SFN of the target base station and CFN of the mobile station, by providing a method that a network knows the frame offset before performing the hard handover.

In a difference way of a convention inter-frequency hard handover having problem of at least more than one frame call disconnection, the present invention provides a method for seamless inter-frequency hard handover by transmitting a preamble (or pilot) through new frequency with a compressed mode, acquainting a synchronization of an uplink by using a preamble (or pilot) transmitted from a target base station before a currently established communication is completely disconnected.

The present invention also performs the hard handover quickly in a network by the target base station transmits the acquisition indicator (AI) according to a received preamble (or pilot) transmitted from a mobile station in a transmission gap (TG).

In a difference way of a convention inter-frequency hard handover having problem of at least more than 50 msec call disconnection in case that a base station controller dose not know a frame offset, which is a difference between SFN of a target base station and CFN of a mobile station,

the present invention provides a method for seamless inter-frequency hard handover by providing a method that a network knows the frame offset before performing the hard handover.

The present invention can be implemented to not only an inter-frequency hard handover in W-CDMA FDD system but also a hard handover to W-CDMA FDD or from GSM to W-CDMA FDD in W-CDMA TDD system.

Brief Description of the Drawings

The above and other objects and features of the present invention will become apparent from the following description of the preferred embodiments given in conjunction with the accompanying drawings, in which:

Fig. 1 is a view illustrating a typical wireless communication system for performing an inter-frequency hard handover;

Fig. 2 is a diagram showing a structure of a typical compressed mode transmission;

Fig. 3 is a diagram depicting an example of an uplink transmission, which transmits a preamble through a new frequency by using a compressed mode of a single frame configuration for a seamless inter-frequency hard handover in accordance with an embodiment of the present invention;

Fig. 4 is a diagram providing an example of an uplink transmission, which transmits a preamble through a new frequency by using a compressed mode of a double frame configuration for a seamless inter-frequency hard handover in accordance with an embodiment of the present invention;

Fig. 5 is a diagram representing an example of uplink and downlink transmission in case of a mobile station having a dual-mode receiver for a seamless inter-frequency hard handover in accordance with an embodiment of the present invention;

Fig. 6 is a diagram illustrating an example of uplink

and downlink transmission in case of a mobile station having single-mode receiver for a seamless inter-frequency hard handover in accordance with an embodiment of the present invention;

Fig. 7 shows a signal flow between systems in case a target base station does not transmit an AI through a downlink when a network knows a frame offset for a seamless inter-frequency hard handover in accordance with the present invention;

Fig. 8 is a diagram illustrating a compressed mode pattern of the 3GPP W-CDMA employed in the present invention;

Fig. 9 exemplifies a timing chart showing that a target base station decides a searching region for a preamble transmitted from a mobile station having a dual-mode receiver in case a frame offset is known to a network for a seamless inter-frequency hard handover in accordance with the present invention;

Fig. 10 presents a signal flow between systems in case a target base station transmits AI through a downlink when a frame offset is known to a network for a seamless inter-frequency handover in accordance with the present invention;

Fig. 11 is a timing chart in case a target base station an AI for detecting a preamble when a frame offset is known to a network for a seamless inter-frequency handover in accordance with the present invention;

Fig. 12 illustrates a signal flow chart in case one class of AI and one class of preamble is transmitted when a frame offset is not known to a network for a seamless inter-frequency handover in accordance with the present invention;

Fig. 13 is a timing chart illustrating that a target base station searches a preamble in a corresponding region of each frame from a moment it receives a preamble search order in case a frame offset is not known to a network for

a seamless inter-frequency handover in accordance with the present invention;

Fig. 14 is a view illustrating that a base station controller calculates a frame offset by using an SFN from a target base station and a CFN from a mobile station in case the frame offset is not known to a network for a seamless inter-frequency handover in accordance with an embodiment of the present invention;

Fig. 15 is a view describing that a base station controller calculates a frame offset by using an SFN of a target base station and a CFN of a mobile station in case the frame offset is not known to a network for a seamless inter-frequency handover in accordance with another embodiment of the present invention;

Fig. 16 is a signal flow chart in case two classes of AI and two classes of preamble are transmitted when a frame offset is not known to a network for a seamless inter-frequency handover in accordance with the present invention;

Fig. 17 shows an example of operations of a mobile station and a target base station in case two classes of AI and two classes of preamble are transmitted when a frame offset is not known to a network for a seamless inter-frequency handover in accordance with the present invention; and

Fig. 18 provides a flowchart illustrating operations of a mobile station and a base station using the method of Fig. 16 for a seamless inter-frequency handover in accordance with the present invention.

Modes for carrying out the Invention

With reference to the accompanying drawings, the preferred embodiments of the present invention will be described in detail hereinafter.

Fig. 1 shows an example of performing a hard handover

between two base stations, i.e., a source base station 2 and a target base station 3. As shown in Fig. 1, the target base station 3 does not support communication frequencies f_1 and f_1' of a mobile station 1.

Figs. 3 and 4 exemplify preamble transmission methods of an uplink, which use an uplink compression mode of the present invention for implementing a seamless inter-frequency hard handover in a same situation is in Fig. 1. Fig. 3 shows a single frame compression mode and Fig. 4 represents a double frame compression mode.

In the present invention, the mobile station 1 transmits a preamble 8 through a new frequency f_2' in a TG region by using the uplink compressed mode before disconnecting the current established frequency f_1'completely as shown in Figs. 3 and 4. At this moment, the preamble 8 transmitted from the mobile station 1 is a direct sequence bandwidth spread signal and a code sequence used for bandwidth spread needs to be known to the target base station 3 before the preamble is transmitted.

For seamless inter-frequency hard handover, before performing the hard handover, the target base station 3 acquires the synchronization of signals transmitted from the mobile station 1 by using the preamble 8 of the uplink at which the mobile station 1 transmits signals through the new frequency f_2' by using the uplink compressed mode.

In the present invention, the mobile station 1 has "Guard Time" before 9 or after 10 transmitting the preamble 8 in the uplink compressed mode, and the target base station 3 and a base station controller 4, i.e., a network should know the "Guard Time" (T_{grd}) 9 before the preamble 8 transmitted. This has to be newly defined in the 3GPP standard.

In the present invention, after the target base station 3 acquires the synchronization of signal transmitted from the mobile station 1 by using the preamble 8 of the uplink transmitted through the frequency f_2', the

target base station 3 can transmit an acknowledgment (ACK) of acquiring the synchronization (through a wired network) to the base station controller 4 or through the downlink of the frequency f_2 to the mobile station 1.

Figs. 5 and 6 show an example that the target base station 3 transmits an acknowledgment for the synchronization in the form of an acquisition indicator (AI) to the mobile station 1 by using the downlink of frequency f_2 after acquiring the synchronization of signals transmitted from the mobile station 1 by using the preamble 8 of the uplink transmitted through the frequency f_2'.

Fig. 5 shows an example of data transmitting between a mobile station and a base station in case of the mobile station having a dual-mode receiver and Fig. 6 shows an example of data transmitting between a mobile station and a base station in case of the mobile station having a single-mode receiver.

As illustrated in Figs. 5 and 6, the AI transmitted by the target base station 3 is not related with a structure of the receiver of the mobile station, whereas a structure of frames transmitted from the source base station 2 and a role of the frames at receiver of the mobile station are depending on the structure of the receiver of the mobile station. That is, in case the mobile station 1 has the single-mode receiver, the source base station 2 transmits the compressed frame in the downlink as shown in Fig. 6 as a frame, which is corresponding to a location of the AI 11 transmitted from the target base station 3, on the other hand, case of the mobile station 1 has the dual-mode receiver, a normal frame is transmitted as shown in Fig. 5.

As shown in Figs. 5 and 6, the target base station 3 transmits the AI after a certain period time is passed by considering the processing time after receiving the preamble 8 from the mobile station 1 and the mobile station 1 has to know a start point of transmitting the AI.

When demodulating the AI, the mobile station with the dual-mode receiver or the single-mode receiver can perform a non-coherent demodulation or can perform a coherent demodulation by using a common pilot channel transmitted through the downlink of the frequency f_2 from the target base station 3. Although it is not shown in the drawings, the target base station 3 transmits other channel of the downlink of the frequency f_2 such as a common pilot channel, a synchronization channel and data channel for other mobile station 1 and so on in a code division scheme.

In case the mobile station 1 has the single-mode receiver, the mobile station 1 uses the common pilot channel of the target base station 3, which is received through the frequency f_2 in the TG region 7, to coherently demodulate the AI.

In case the mobile station 1 has the single-mode receiver 1, the "Guard Time" 13 has to exist between the end of the AI transmission and the end of the TG region.

In the uplink preamble transmission method of the present invention shown in Figs. 3 to 6, the mobile station 1 can transmit a same preamble several times by repeating the compressed mode several times so as to increase the probability of the target base station acquiring the synchronization. At this moment, the compressed mode pattern is transmitted from the base station controller 4 to the mobile station 1 and the target base station 3. Also, in the AI transmission of the downlink described in Figs. 5 and 6, the target base station 3 can transmit the AI several times to increase the probability of the mobile station 1 detecting the AI. Parameters related to the compressed mode pattern are defined in the 3GPP TS25. 525 standard.

Fig. 7 is a diagram illustrating a signaling procedure between the mobile station 1, the source base station 2, the target base station 3 and the base station controller 4 during performing the hard handover in case

that the frame offset is known to the base station controller 4 and the target base station 3 does not transmit the acquisition indication (AI) for the acquisition of the downlink preamble to the mobile station 1, wherein the frame offset is a difference between the SFN of the target base station 3 and the CFN of the mobile station 1.

In Fig. 7, it is assumed that the frame offset is known to the base station controller 4 but the target base station 3 does not transmit the AI to the downlink. Referring to Fig. 7, at time0 14, the mobile station 1 and the source base station 2 are communicating through the frequency f_1 (f_1'); the target base station 3 has resources to support the mobile station 1 through the frequency f_2 (f_2'); the frame offset and a chip offset were known to the base station controller 4 which $OVSF_{target}$ from the target base station 3, the mobile station acquired the synchronization of the downlink of the target base station 3; and the target base station 3 does not acquire the synchronization of the uplink.

That is, at the time0 14, the mobile station 1 and source base station 2 are communicating through f_1 (downlink) and f_1' (uplink); the target base station 3 has reported to the base station controller 4 that there are resources at the f_2 (f_2') link to support the mobile station 1 and also the target base station 3 has reported an orthogonal variable spreading factor (OVSF) code of the downlink to be used by the mobile station 1 at the downlink to the base station controller 4 after performing the handover.

As mentioned above, the base station controller 4 already knows the frame offset and the chip offset at the time0 14. Herein, the frame offset represents the difference between the SFN of the target base station 3 and the CFN of the mobile station 1 and it is defined in the standard TS25. 402 (Release'99) of 3GPP. Also, the SFN is

a frame number of a common control channel of the downlink and has a range of 0 to 4095 and the CFN is a transport channel frame number, having a range of 0 to 255 and is determined after a communication link between the mobile station 1 and a base stations is established.

The base station controller 4 can know the frame offset by receiving the frame offset from the mobile station before the time0 14 in case the mobile station 1 has a dual-mode receiver or analogizing the frame offset from information reported from other base stations. The chip offset is a difference between frame boundary of a transport channel of the mobile station 1 and a frame boundary of a common control channel of the target base station 3 and has a range of 0 to 38399 chips. The mobile station 1 measures the chip offset by using the dual-mode receiver or using the compressed mode in case of a single mode receiver and the measured chip offset transmitted to the base station controller 4. The chip offset is defined in TS25. 402 (Release'99).

Also, at the time0 14, the mobile station 1 has acquired the synchronization of the downlink of the target base station 3 while the target base station 3 has not acquired the synchronization of the uplink.

The base station controller 4, which knows the frame offset, transmits the transport channel frame number (TGCFN) of starting the compressed mode in the uplink of the mobile station 1 after the time0 14, information for a starting slot number of the TG (TGSN), information for the compressed mode pattern (TGL1, TGL2, TGD, TGPL1, TGPL2) and information for a total length of the compressed-mode TGPRC to the mobile station 1 before TGCFN.

Fig. 8 shows parameters for the compressed mode pattern defined in the 3GPP TS25.215. The mobile station 1 transmits the uplink preamble at a time decided by the compressed mode pattern received from the base station controller 4. The mobile station 1 uses an open loop power

control when transmitting the fist preamble. That is, the mobile station 1 determines a transmission power of the first preamble by using the intensity of received signals measured at the downlink f_2 of the target base station 3 before the time0 14 or a signal to noise rate (Ec/Io) of received signals at the common pilot channel.

Also, the controller of base station 4, which knows the frame offset, transmits a transport channel frame number (TGCFN) of starting uplink compressed mode of the mobile station 1 after the time0 14, information for a starting slot number of each TG (TGSN), information of the compressed mode pattern (TGL1, TGL2, TGD, TGPL1, TGPL2), information of total length of the compressed mode (TGPRC), a frame offset, information for a chip offset and a scrambling code number (SCID) to the target base station 3 before the TGCFN 16 in step 16.

After then, the target base station 3 acquires the synchronization of the preamble transmitted from the mobile station 1 by using the frame offset, the chip offset information, the SCID and the compressed mode pattern received from the base station controller 4.

Fig. 9 provides a timing chart illustrating that the target base station 3 decides a searching region for the preamble transmitted from the mobile station 1 by using the information from the base station controller 4.

Referring to Fig. 9, it is assumed that the mobile station 1 has the dual-mode receiver.

At first, the target base station 3 calculates the SFN corresponding to the TGCFN by using the frame offset and a following equation EQ. 1.

$$\text{SFN mod } 256 = (\text{frame offset} + \text{TGCFN}) \text{ mod } 256 \qquad \text{EQ. 1}$$

Since in the equation EQ. 1, the range of the SFN is 4096 and that of the TGCFN is 256, there are 16 SFNs satisfying the equation EQ. 1. For example, if the frame

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offset is 67 as shown in Fig. 9, the SFNs become 123, 379, 635, ….

A base station searcher selects an SFN whose value is closest to a frame corresponding to a time of receiving a preamble searching order from the base station controller 4 among the 16 possible SFNs as the SFN corresponding to the TGCFN. Therefore, in Fig. 9, "123" is selected as the SFN corresponding to the TGCFN since the "123" is closest to a time "120", which is a time of receiving the preamble searching order from the base station controller 4. The target base station 3 searches the uplink preamble by setting up a searching region from a time 17, which is β chips away from boundary of a corresponding frame (e.g., 123 frame in Fig. 9), to a time which is "preamble length + $2\tau_{max}$". Herein, β is defined as follows:

$$\beta = \text{chip offset} + \text{TGSN} \times 2560 + T_o + T_{grd} \quad \text{EQ. 2}$$

In the equation EQ. 2, T_o is a difference between a downlink time (DL $DPCH_{nom}$) and an uplink time of the mobile station 1 and it is defined as 1024 chips in the 3GPP standard. As before mentioned T_{grd} is a Guard Time before the mobile station 1 transmits the preamble and the T_{grd} should be known to the target base station 3. β may be larger or smaller than 38400 chips.

In Fig. 9, $2\tau_{max}$ is the maximum round trip delay corresponding to a cell coverage of the target base station 3 and equal to a search window size of the target base station 3. If it is assumed that the chip transmission speed is 3.84 Mcps and the cell coverage is 20 km, $2\tau_{max}$ becomes almost 512 chips.

In case the preamble searching is failed, the target base station 3 searches the uplink preamble by setting up the search region from a time 18, which is β chips away from a boundary of a next frame (e.g., 129 frame in Fig. 9)

designated by a compressed mode pattern received from the controller of base station 4, to a time, which is "preamble length + $2\tau_{max}$". The target base station 3 repeatedly performs the above-mentioned procedure until the preamble is detected.

The target base station 3 acquires the uplink synchronization by using the configuration of Fig. 9 and reports it to the base station controller 4 in step 19. At this moment, the target base station 3 also transmits the receiving intensity of the preamble (e.g., E_c/I_o value) transmitted from the mobile station 1. Then, in step 20, the base station controller 4 instructs the source base station 2, the mobile station 1 and the target base station 3 to perform the handover. At this time, the base station controller 4 transmits a CFN at a time at which the handover starts to the source base station 2, the mobile station 1 and the target base station 3 and further transmits $OVSF_{target}$ to be used as a channel spread code of a new downlink in the handover to the mobile station 1.

The mobile station 1, which received the handover instruction from the base station controller 4, stops transmitting the preamble using the compressed mode. Also, the mobile station 1 disconnects the call with the source base station 2 at the CFN received from the base station controller 4 and starts to communicate with the target base station 3 by using a new frequency f_2 (f_2') in step 21. Before starting to the communicate between the target base station 3 and the mobile station 1 at the corresponding CFN, the uplink and the downlink have been already synchronized by the method of the present invention and, therefore, a call disconnection there between does not occur.

Fig. 10 is a diagram illustrating a signaling procedure between the mobile station 1, the source base station 2, the target base station 3 and a base station controller 4 during performing the hard handover in case that the frame offset is known to the base station

controller 4 and the target base station 3 transmits the AI for the synchronization acquisition for the uplink to the mobile station 1.

In Fig. 10, it is assumed that the base station controller 4 knows the frame offset and the target base station 3 transmits the AI through the downlink. In Fig. 10, at a time0 14, the mobile station 1 and the source base station 2 are communicating with each other through f_1 (f_1'), the target base station 3 has resources at the f_2 (f_2') link to support the current mobile station 1; the base station controller 4 knows the frame offset and chip offset and has received $OVSF_{target}$ from the target base station 3; the mobile station 1 has acquired already the synchronization of the downlink of the target base station 3; and the target base station 3 does not acquire the synchronization of the uplink yet.

The signaling procedure of Fig. 10 is similar to that of Fig. 7 but the base station controller 4 transmits not only parameters related to a compressed mode pattern but also $OVSF_{target}$ code information to be used for the downlink in the handover, when the base station controller 4 instructs the mobile station 1 to transmit an uplink preamble in step 22. Also, after acquiring the uplink synchronization, in step 22, the target base station 3 transmits the AI for the synchronization through the downlink by using a configuration shown in Fig. 11.

When transmitting the AI, the target base station 3 uses an $OVSF_{target}$ code as a channel spread code, wherein the $OVSF_{target}$ code is identical to the $OVSF_{target}$ code sent when instructing the mobile station 1 to transmit the uplink preamble in the step 22, and the mobile station 1 uses the $OVSF_{target}$ when demodulating the AI.

In a method shown in Fig. 10, in which the target base station 3 transmits the AI in case the base station controller 4 knows the frame offset, the procedure of searching the uplink preamble performed by the target base

station 3 is identical to a method shown in Fig. 1 in which the target base station 3 down not transmit the AI.

Fig. 11 shows an example that the target base station 3 succeeds in detecting a preamble at a second time after failing to detect preamble at a first time, wherein the preamble is transmitted from the mobile station, having a single-mode receiver.

The target base station 3 transmits the AI after succeeding in detecting the uplink preamble, and the AI is transmitted at a second point 24, which is γ chips away from a first point, β chips away from a boundary of a frame designated by the compressed mode pattern, wherein the designated frame is a 129 frame in Fig. 11. In here, β is defined in the equation EQ. 2 and γ should satisfy a following equation EQ. 3. The γ has to be known to the target base station 3 and the mobile station 1 and, therefore, this should be newly defined in the 3GPP standard.

$$\gamma > 2\tau_{max} + T_{pre} \qquad \text{EQ. 3}$$

The mobile station 1 demodulates the AI at times, at which the mobile station is expected to receive the AI, such as 25 and 26 in Fig. 11, wherein the mobile station 1 has known β and γ and acquired a frame boundary 27 of signals received from the target base station 3. In case the mobile station has the single-mode receiver, as like in Fig. 11, the compressed mode of downlink is used. The mobile station 1, which received the AI does not transmit the preamble any more. If it fails to detect the AI, the mobile station 1 re-transmits the preamble in a next compressed mode region. After transmitting the preamble, if the preamble is detected again in a next compressed mode, the target base station 3 re-transmits the AI.

The target base station 3 detecting the preamble

reports the detection of the preamble to the base station controller 4 and then the base station controller 4 instructs the source base station 2, the mobile station 1 and the target base station 3 to perform the handover. At this moment, the base station controller 4 transmits the CFN at a point of the handover started to the source base station 2, the mobile station 1 and the target base station 3. The mobile station 1, which received the handover instruction from the base station controller 4, disconnects communication with the source base station 2 at the CFN and starts to communicate with the target base station 3 by using the new frequency f_2 (f_2'). Before starting to the communicate with the target base station 3 and the mobile station 1 at corresponding CFN, synchronization with the uplink and downlink is acquired by using the method of the present invention and, therefore, the call disconnection there between does not occur.

In the W-CDMA FDD standard (Release' 99) of the 3GPP, if the base station controller 4 does not know the frame offset, which is a difference between the SFN of the target base station 3 and the CFN of the mobile station 1, when performing the handover, the mobile station 1 disconnects the established frequency completely and re-acquires the SFN of the target base station 3 through a new frequency for performing the hard handover. Therefore, at least 50 msec of additional call disconnection may occur between the mobile station 1 and the target base station 3.

For the case that the base station controller 4 does not know the frame offset, the handover method of the present invention forces the base station controller to know the frame offset before performing the handover by using the AI transmitted from the target base station 3 to the mobile station 1. This will be explained in detail with reference to Fig. 12.

Fig. 12 shows a signaling procedure between the mobile station 1, the source base station 2, the target

base station 3 and the base station controller 4 during performing the hard handover in case that the base station controller 4 does not know the frame offset.

In Fig. 12, it is assumed that the base station controller 4 does not know the frame offset. At time0 28 in Fig. 12, the mobile station 1 and the source base station 2 are communicating with each other through the frequency f1 (f1'); the target base station 3 has resources at the f2 (f2') link to support the mobile station 1; the base station controller 4 knows the chip offset but does not know the frame offset, and has received $OVSF_{target}$ from the target base station 3; the mobile station 1 has already acquired the synchronization of the downlink of the target base station 3; and the target base station 3 does not acquire the synchronization of the uplink yet.

That is, at time0 28, the mobile station 1 and the source base station 2 are communicating with each other through the frequencies f_1 (downlink) and f_1' (uplink); the target base station 3 has reported to the base station controller 4 that there are resources at the f2 (f2') link to support the mobile station 1; and an orthogonal variable spreading factor (OVSF) code of the downlink has been already reported to the base station controller 4, wherein the OVSF code will be used in the downlink by the mobile station 1 after the handover performed.

As mentioned above, the base station controller 4 knows the chip offset but does not know the frame offset at time0 28.

The signaling procedure shown in Fig. 12 is similar to that in Fig. 10. However, the base station controller 4 does not transmit the frame offset information to the target base station 3 when instructing the target base station 3 to search an uplink preamble in step 30. It is because the base station controller 4 does not know the frame offset information.

The target base station 3, which received the

DOCID: <WO 02058280A1 I >

preamble searching instruction in the step 30, performs the preamble searching process for a corresponding region of the frame from the moment of receiving the preamble searching order. This is illustrated in Fig. 13.

Since the target base station 3 does not know an SFN of a frame through which the mobile station 1 transmits the preamble but know β being information for a slot at which the preamble starts, the target base station 3 sets up searching regions (38, 39, 40,....) from a boundary of each frame to a point, which is $2\tau_{max}$ away from an offset of β $_{mod}$ 38400 and searches the preamble. In here, "$_{mod}$ 38400" is used because, as mentioned, β may be larger than 38400.

The target base station 3, which succeeded in searching the preamble, transmits the AI to the mobile station 1 through the downlink, and, at the same time, reports the acquisition of the uplink synchronization to the base station controller 4 in step 33. At this time, the SFN corresponding to the AI is also transmitted. After then, the mobile station 1, which received the AI from the target base station 3, transmits a CFN of the frame corresponding to the received AI to the base station controller 4 in step 34. At this time, the base station controller 4 calculates the frame offset in step 35 by using the SFN received from the target base station 3 and the CFN information received from the mobile station 1 for the AI transceiving time.

Figs. 14 and 15 show a procedure of calculating the frame offset performed in the base station controller 4 by using the SFN information received from the target base station 3 and the CFN information received from the mobile station 1.

After calculating $(\beta + \tau)$ $_{mod}$ 38400, if the calculated value is smaller than the chip offset, the base station controller 4 determines the value of the frame offset as (SFN-CFN-1) $_{mod}$ 256 and, if otherwise, decides the value of

the frame offset as $(SFN-CFN)_{mod}\ 256$. This is shown in an equation EQ. 4.

$$\text{frame offset} = (SFN-CFN-1)_{mod}\ 256 \quad \text{for } (\beta + \tau)_{mod} 38400 < \text{chip offset}$$
$$\text{frame offset} = (SFN-CFN)_{mod}\ 256 \quad \text{for } (\beta + \tau)_{mod} 38400 \geq \text{chip offset}$$

EQ. 4

When transmitting the AI, the target base station 3 uses the $OVSF_{target}$ code, which is identical to the $OVSF_{target}$ used when sending the uplink preamble transmitting instruction in the step 22 to the mobile station 1, as a channel spread code and the mobile station 1 uses the same $OVSF_{target}$ when demodulating the AI.

After calculating the frame offset, the base station controller 4 instructs the source base station 2, the mobile station 1 and the target base station 3 to perform the handover in steps 36 and 37. At this time, the base station controller 4 provides the mobile station 1 with the CFN in which the handover is performed and, in turn, the mobile station 1 disconnects the current communication link with the source base station 2 at the CFN and starts to communicate with the target base station 3 through a new frequency f_2 (f_2').

The base station controller 4 transmits the calculated frame offset and the CFN at which the handover is performed to the target base station 3 in step 37. At this time, the target base station 3 calculates an SFN corresponding to the CFN at which the handover is performed by using the frame offset received from the base station controller 4 and receives an uplink DPCH at the same time transmitting, a downlink DPCH from the moment corresponding to the calculated SFN in step 38.

As mentioned above, although the base station controller 4 does not know the frame offset, the handover

method of the present invention forces the base station controller 4 to know the frame offset before performing the handover by using the AI transmitted from the target base station 3 to the mobile station 1 and transmits the frame offset the target base station 3 together with the handover instruction, so that, it is possible to perform the seamless inter-frequency hard handover.

Fig. 16 shows a signaling procedure of a method using two classes of preambles and two classes of AIs in each of the mobile station 1 and the base station to minimize false handover instruction given by the base station controller 4 by minimizing the false detection probability of the mobile station 1 and the target base station 3 in case the base station controller does not know the frame offset.

The mobile station 1, which received a preamble transmitting instruction from the base station controller 4 transmits the $preamble_1$ through the frequency f_2' by using the uplink compressed mode in step 41. At this time, the target base station 3, which received the preamble searching instruction from the base station controller 4 searches the $preamble_1$ according to the above-mentioned procedure described in Fig. 13. After succeeding in searching the $preamble_1$, the target base station 3 transmits an AI_1, which is an acknowledgement for succeeding in searching the $preamble_1$, the frequency f_2 in step 42. And then, the mobile station 1 detects the AI_1, which is transmitted to the frequency f_2, by using the downlink compressed mode or the dual-mode receiver and, in turn, transmits a $preamble_2$ to a frequency f_2' at a next compressed frame in step 43.

After transmitting the $preamble_2$, the target base station 3 detects the $preamble_2$ transmits an AI_2, which is an acknowledgement for achieving to detect the $preamble_2$, to the mobile station 1, and reports the acquisition of the uplink synchronization to the base station controller 4 at the same time of notifying an SFN through which the AI_2 is

transmitted to the base station controller 4 in step 45.

The mobile station 1 detects the AI_2 received through the frequency f_2 by using the downlink compressed mode or the dual-mode receiver and reports the detection of AI_2 to the base station controller 4 at the same time of notifying, CFN through which the AI_2 is also received to the base station controller 4 in step 46. And then, the base station controller 4 calculates the frame offset by using the equation EQ. 4 with the SFN transmitted from the target base station 3 and the CFN transmitted from the mobile station 1 and invokes the source base station 2, the target base station 3 and the mobile station 1 to perform the handover in the steps 36 and 37. At this moment, the calculated frame offset is transmitted to the target base station 3. Steps after transmitting the calculated frame offset are same as the steps in Fig. 12.

Fig. 17 shows an example of an AI transmission of a base station and a preamble transmission of the mobile station 1 when the method in Fig. 16 is used.

The mobile station 1 uses an open loop power P0 to transmit a $preamble_1$ at the first time and in case of failing to receive the AI_1, increases the power up to P1 to re-transmit the $preamble_1$. In case of failing to receive the AI_1, the above mentioned steps are performed repeatedly and in case of achieving to receive the AI_1, a $preamble_2$ is transmitted by using a power identical to the power by which the preamble, is thereby transmitted.

When using the method described in Fig. 16, in case that the base station controller 4 does not know the frame offset, a transmission cycle of the preamble of the mobile station 1 has to be constant. "T" in Fig. 17 represents the transmission cycle of the preamble. That is, the base station controller 4, which does not know the frame offset, should transmit a compressed mode pattern satisfying by the above requirement to the mobile station 1 and the target base station 3.

OCID: <WO 02058280A1 I >

Fig. 18 is a flowchart explaining operations of the mobile station and the base station, which use the method of Fig. 16.

At first, the mobile station 1, which received a preamble transmission instruction from the base station controller 4 in step 29, transmits the $preamble_1$ by using the uplink compressed mode in step 41 and then, detects the AI_1 in step 48. In the step 48, if the AI_1 is not detected, the mobile station 1 re-transmits the $preamble_1$ in the step 41, after increasing the power as much as Δ in step 47. On the other hand, if the AI_1 is detected, at a next compressed mode, the mobile station 1 transmits the $preamble_2$ by using a power identical to the power by which the preamble1 is finally transmitted in step 43.

After transmitting the $preamble_2$, if the detection of the AI_2 is achieved in step 49, the mobile station 1 transmits a CFN at which the AI_2 is received to the base station controller 4 in step of 46 and, if the detection of the AI_2 is failed in the step of 49, the mobile station 1 notices the failure of detecting the AI_2 to the base station controller 4 in step 50.

Meanwhile, the target base station 3, which received a preamble search instruction from the base station controller 4 in step 30, searches the $preamble_1$ in every search region in step 51 by using the procedure of Fig. 13 and the target base station 3 transmits the AI_1 for the search region, at which the $preamble_1$ is detected, to the mobile station 1 in step 42. Therefore, the AI_1 may be transmitted more than one time during the T in Fig. 17. In step 52, the target base station 3 detects the $preamble_2$ from a next expected point corresponding to the search region at which the AI_1 is transmitted in step 52. At the step 52, if the $preamble_2$ is detected, the AI_2 is transmitted to the mobile station 1 and the searching process is terminated. And a SFN, at which the AI_1 is transmitted, is transmitted to the base station controller.

If the $preamble_1$ or the $preamble_2$ are not detected, the above-mentioned procedures are performed repeatedly.

The base station controller calculates a frame offset value when it receives both of the CFN and SFN from the mobile station 1 and the base station and produces a handover instruction. In case that the base station controller receives a message of the failure to detect the AI_2 from the mobile station 1, does not receive the SFN for a certain duration after receiving the CFN, does not receive the CFN a predetermined duration after receiving the SFN, or receives no information for a time of TGPRC from the target base station 3 and the mobile station 1, the above-mentioned all steps are preformed again.

The above-mentioned steps of the method of the present invention can be implemented as a program and can be stored in a computer readable recording medium such as CD-ROM, RAM, ROM, floppy disk, hard disk and magneto-optical disk.

The present invention, as mentioned above, transmits a preamble (or a pilot), which is direct sequence spread to a new frequency for a short time by using an uplink compressed mode or a similar method to the uplink compressed mode before a mobile station completely disconnects a currently established communication in an inter-frequency hard handover situation described in Fig. 1. As a result, the present invention makes the seamless inter-frequency hard handover possible by allowing the target base station to acquire the uplink synchronization before the mobile station completely disconnects the currently established communication. Furthermore, in case that the base station controller 4 does not know the frame offset, which is a difference between the SFN of the target base station and the CFN of the mobile station, the present invention can prevent a call disconnection by forcing the network to know the frame offset by using an AI, which is transmitted through a downlink by using a new frequency

from the target base station, just before performing the hard handover.

While the present invention has been described with respect to certain preferred embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined in the following claims.

Claims:

1. A method for performing seamless inter-frequency hard handover in a radio communication system, comprising the steps of:

a) a mobile station, disconnecting a first uplink carrier frequency used for communication, transmitting a direct sequence spread preamble signal through a second uplink carrier frequency for a short time, and continuously performing the communication through the first uplink carrier frequency;

b) a target base station, acquiring an uplink synchronization of the mobile station by using the direct sequence spread preamble; and

c) performing the hard handover by using the uplink synchronization.

2. The method as recited in claim 1, further comprising the steps of:

d) the target base station, after acquiring the uplink synchronization of the preamble, transmitting an AI as an acknowledgment of the acquisition of the uplink synchronization by using a new downlink frequency; and

e) the mobile station, detecting the AI.

3. The method as recited in claim 2, further comprising the step of f) re-transmitting the preamble by increasing a transmission power if the mobile station does not receive the AI from the target base station.

4. The method as recited in claim 2, further comprising the step of f) in case a base station controller does not know a frame offset, which is a difference between a connection frame number (CFN) of the mobile station and a system frame number (SFN) of the target base station, calculating the frame offset by using the SFN used for

transmitting the AI and a CFN used for receiving the AI, which are transmitted from the target base station and the mobile station, respectively, and transmitting the calculated frame offset to the target base station.

5. The method as recited in claim 1, further comprising the step of d) in case a base station controller knows a frame offset, the target base station, acquiring the uplink synchronization by using the preamble and reporting the acquisition of the uplink synchronization only to the base station controller.

6. The method as recited in claim 5, wherein the step a) includes the steps of:

a1) the base station controller, transmitting a transport channel frame number (TGCFN), at which the mobile station starts an uplink preamble transmission, a slot number (TGSN) and compressed mode pattern parameters, TGL1, TGL2, TGD, TGPL1, TGPL2 and TGPRC, to the mobile station after a time0 at which the mobile station is communicating with a source base station through the first carrier frequency and acquires the synchronization of a new downlink, the target base station has resources to support the mobile station but does not acquire the uplink synchronization and the base station controller knows the frame offset and a chip offset; and

a2) the mobile station, transmitting the preamble during a transmission gap (TG) of a corresponding compressed frame through the second uplink carrier frequency by using compressed mode information,

the step b) including the steps of:

b1) the base station controller, transmitting the TGCFN, the TGSN, the mode parameters, TGL1, TGL2, TGD, TGPL1, TGPL2 and TGPRC, a scrambling code identification (SCID), the frame offset and the chip offset to the target base station, thereby allowing the target base station to

search the preamble transmitted from the mobile station in a preset time;

b2) the target base station, searching the preamble by using the compressed mode information, the frame offset, the chip offset and the SCID; and

b3) the target base station, after achieving the preamble searching, reporting the success of searching the preamble to the base station controller by the target base station, and

the step c) including the steps of:

c1) the base station controller, instructing the source base station and the mobile station to perform the handover and at the same time, transmitting orthogonal variable spreading factor (OVSF) information, which is used for establishing a new link, a transport channel frame number, of the mobile station, at which the handover is performed, CFN and information for an uplink transmission power, which is used by the mobile station just after the handover is performed;

c2) the base station controller, instructing the target base station to perform the handover and at the same time, transmitting the CFN at which the handover is performed; and

c3) the mobile station and the target base station, establishing communication there between through the new link at the CFN.

7. The method as recited in claim 1, further comprising the step of d) in case a base station controller knows a frame offset, the target base station, transmitting an AI through a new downlink of the second carrier frequency after acquiring the uplink synchronization by using the preamble and reporting the acquisition of the uplink synchronization the base station controller.

8. The method as recited in claim 7, wherein the step a) includes the steps of:

a1) the base station controller, transmitting a transport channel frame number (TGCFN), at which the mobile station starts an uplink preamble transmission, a slot number (TGSN), compressed mode pattern parameters, TGL1, TGL2, TGD, TGPL1, TGPL2 and TGPRC, and orthogonal variable spreading factor (OVSF) code information to be used as a channel spread code of the AI through the new downlink to the mobile station after a time0 at which the mobile station is communicating with a source base station through the first carrier frequency and acquires the synchronization of a new downlink, the target base station has resources to support the mobile station but does not acquire the uplink synchronization and the base station controller knows the frame offset and a chip offset; and

a2) the mobile station, transmitting the preamble during a transmission gap (TG) of a corresponding compressed frame through the second uplink carrier frequency by using compressed mode information,

the step b) including the steps of:

b1) the base station controller, transmitting the TGCFN, the TGSN, the compressed mode parameters, TGL1, TGL2, TGD, TGPL1, TGPL2 and TGPRC, a scrambling code identification (SCID), the frame offset and the chip offset to the target base station, thereby allowing the target base station to search the preamble transmitted from the mobile station is a preset time;

b2) the target base station, searching the preamble by using the compressed mode information, the frame offset, the chip offset and the SCID;

b3) the target base station, after achieving the preamble searching, transmitting an AI spread to the OVSF through the new downlink as a response of the success of searching the preamble; and

b4) the target base station, after achieving the

preamble searching, reporting the success of searching the preamble to the base station controller, and

the step c) including the steps of:

c1) the base station controller, instructing the source base station and the mobile station to perform the handover and at the same time, transmitting a connection frame number (CFN) of the mobile station, at which the handover is performed, and information for an uplink transmission power, which is used by the mobile station just after the handover is performed;

c2) the base station controller, instructing the target station to perform handover and at the same time, transmitting the CFN at which the handover is performed; and

c3) the mobile station and the target base station, establishing communication there between through a new link at the CFN, wherein the OVSF code, which is used for transmitting the AI, is used for a communication channel of the new downlink.

9. The method as recited in claim 2, wherein, if the mobile station employs a single-mode receiver, a last frame of the first carrier frequency for the communication established between the mobile station and a source base station and a first frame after the preamble is transmitted to the target base station are operated as compressed frames and, between the two frames, there is a guard time for a frequency conversion of the mobile station.

10. The method as recited in claim 4, wherein the step a) includes the steps of:

a1) for making the base station controller know the frame offset just before instructing the mobile station and the target base station to perform the handover, the base station controller, transmitting a transport channel frame number (TGCFN), at which the mobile station starts an

uplink preamble transmission, a slot number (TGSN), compressed mode pattern parameters, TGL1, TGL2, TGD, TGPL1, TGPL2 and TGPRC, and an orthogonal variable spreading factor (OVSF) code information to be used as a channel spread code of the AI through a new downlink to the mobile station after a time0, at which, the mobile station is communicating with a source base station through the first carrier frequency and acquires the synchronization of the new downlink, the target base station has resources to support the mobile station but does not acquire the uplink synchronization and the base station controller knows a chip offset but does not know the frame offset; and

a2) the mobile station, transmitting the preamble during a transmission gap (TG) of a corresponding compressed frame through the second uplink carrier frequency by using compressed mode information,

the step b) including the steps of:

b1) the base station controller, transmitting TGCFN, the TGSN, the compressed mode parameters TGL1, TGL2, TGD, TGPL1, TGPL2 and TGPRC, a scrambling code identification (SCID) and a chip offset to the target base station, thereby allowing the target base station to search the preamble transmitted from the mobile station in a preset time;

b2) the target base station, searching the preamble in each frame by using the compressed mode information, the chip offset and the SCID from directly after the target base station receives a preamble search instruction from the base station controller;

b3) the target base station, after achieving the preamble searching, transmitting an AI spreaded by the OVSF through the new downlink as a response of the success of searching the preamble search to the mobile station;

b4) the target base station, reporting an SFN of the target base station, which transmits the AI, to the base station controller; and

b5) the mobile station, reporting a CFN of the mobile station, at which the AI is detected, to the target base station after succeeding to detect the AI and stopping transmitting the preamble, and

the step c) including the steps of:

c1) the base station controller, instructing the source base station and the mobile station to perform the handover and at the same time, transmitting a connection frame number (CFN) of the mobile station, at which the handover is performed, and information for an uplink transmission power, which is used by the mobile station just after the handover is performed;

c2) the base station controller, instructing the target station to perform the handover and, at the same time, transmitting the CFN of the mobile station, at which the handover is performed, and the frame offset to the target base station; and

c3) the mobile station and the target base station, establishing communication there between through a new link at the CFN, wherein the OVSF code, which is used for transmitting the AI, is used for a communication channel of the new downlink.

11. A method for performing a seamless inter-frequency hard handover in a radio communication system in case that a base station controller (or a radio network) dose not know a frame offset, which is a difference between a connection frame number (CFN) of a mobile station and a system frame number (SFN) of a target base station, comprising the steps of:

a) the mobile station, completely disconnecting a first uplink carrier frequency used for communication, transmitting a direct sequence spread preamble (or pilot) through a second uplink carrier frequency for a short time, and continuously performing the communication through the first uplink carrier frequency;

b) the target base station, acquiring an uplink synchronization of the mobile station by using the preamble before performing the hard handover;

c) the target base station, after acquiring the uplink synchronization, transmitting a direct sequence spread AI as a response for the acquisition of the uplink synchronization for a short time through a new downlink frequency;

d) the mobile station, detecting the AI;

e) the base station controller, calculating a frame offset by using the SFN, which is used for transmitting the AI and the CFN, which is used for receiving the AI, and transmitting the calculated frame offset to the target base station; and

f) the base station controller, instructing the mobile station and the target base station to perform the handover.

12. The method as recited in claim 11, wherein the method uses an orthogonal variable spreading factor (OVSF) code, which is used in a communication channel of the downlink when hard handover is performed through a new link, as a channel spreading code of the AI in case that the target base station transmits the AI as the response for the acquisition of the uplink synchronization through the new downlink frequency.

13. The method as recited in claim 12, wherein the target base station transmits the AI at least more than one time to increase the probability of detecting the AI of the mobile station.

14. The method as recited in claim 11, wherein the mobile station uses an uplink compressed mode pattern for the inter-frequency hard handover.

15. The method as recited in claim 14, wherein the

mobile station uses a scrambling code operating in a normal mode when transmitting the preamble while using the uplink compressed mode pattern for the inter-frequency hard handover.

16. The method as recited in claim 11, wherein the occurrence of false handover instruction by the base station controller is minimized by classifying the AI to a first AI (AI_1) and a second AI (AI_2), and the preamble to a first preamble ($preamble_1$) and a second preamble ($preamble_2$) for decreasing the false detection probability of the target base station and the mobile station in case the base station controller does not know the frame offset.

17. The method as recited in claim 16, wherein the AI_1 and AI_2 are distinguished with each other according to a binary orthogonal transform method using an orthogonal code.

18. The method as recited in claim 16, wherein the $preamble_1$ and the $preamble_2$ use an identical scrambling code, and are distinguished with each other according to a binary orthogonal transform method using a orthogonal code.

19. The method as recited in claim 11, wherein the mobile station performs a coherent demodulation to detect the AI by using a common pilot channel (CPICH) transmitted through the frequency through which the AI is transmitted.

20. The method as recited in claim 11, wherein the target base station stores signals received during a transmission gap (TG) of a compressed mode, at which the mobile station transmits the preamble, and then searches the preamble by using signals stored in a time, which the mobile station does not transmit the preamble.

21. The method as recited in claim 16, wherein the

step c) includes the steps of:

c1) the target base station, transmitting the first AI (AI_1) the mobile station through the new downlink frequency as a response for the success of searching the first preamble;

c2) the target base station, detecting the second preamble ($preamble_2$) in a next compressed frame after transmitting the first AI (AI_1);

c3) the target base station, transmitting the second AI (AI_2) to the mobile station when detecting the second preamble ($preamble_2$), reporting a success of acquiring the uplink synchronization to the base station controller and at the same time of noticing a SFN at which the second AI (AI_2) is transmitted; and

c4) the target base station, detecting the first preamble again when it failed to detect the second preamble ($preamble_2$),

the step d) including the steps of:

d1) the mobile station, transmitting the second preamble ($preamble_2$) in the next compressed frame with the same power as used before when succeeding to detect the first AI (AI_1) and transmitting the first preamble ($preamble_1$) again when failing to detect the first AI (AI_1);

d2) the mobile station, reporting the detection of the second AI (AI_2) to the base station controller in case that the mobile station is success to detect the second AI (AI_2) after transmitting the second preamble ($preamble_2$) and, at the same time, transmitting a CFN, at which the second AI (AI_2) is detected to the base station controller; and

d3) the mobile station, reporting the failure of detecting the second AI (AI_2) to the base station controller in case that the mobile station fails to detect the second AI (AI_2), after transmitting the second preamble ($preamble_2$),

the step e) including the steps of:

e1) the base station controller, calculating the

frame offset when it received the CFN and the SFN from the mobile station and the target base station, respectively;

e2) the base station controller, instructing a home base station and the mobile station to perform the handover and, at the same time, transmitting the CFN of the mobile station, which performs the handover, and information for an uplink transmission power to be used by the mobile station directly after performing the handover; and

e3) the base station controller, instructing the target base station to perform the handover and, at the same time, transmitting the frame offset and the CFN of the mobile station, which performs the handover, and

the step f) including the steps of:

f1) establishing a new communication link between the mobile station and the target base station at the CFN, wherein a downlink of the new communication link uses an orthogonal variable spreading factor (OVSF) code, which is used in transmitting the AI; and

f2) repeating the steps C1) to e3) in case that the base station controller receives a message of failing to detect the AI_2 from the mobile station, does not receive the SFN for a certain time after receiving the CFN, does not receive the CFN for a preset time after receiving the SFN, or does not receive any information from the mobile station and the target base station until a predetermined time is expired.

22. A computer readable record medium for storing instructions for executing seamless inter-frequency handover, comprising the functions of:

a) a mobile station, disconnecting a first uplink carrier frequency used for communication, transmitting a direct sequence spread preamble signal through a second uplink carrier frequency for a short time, and continuously performing the communication through the first uplink carrier frequency;

b) a target base station, acquiring an uplink synchronization of the mobile station by using the direct sequence spread preamble; and

c) performing the hard handover by using the uplink synchronization.

23. The computer readable record medium as recited in claim 22, further comprising the functions of:

d) the target base station, after acquiring the uplink synchronization of the preamble, transmitting an AI as an acknowledgment of the acquisition of the uplink synchronization by using a new downlink frequency; and

e) the mobile station, detecting the AI.

24. The computer readable record medium as recited in claim 23, further comprising the function of f) re-transmitting the preamble by increasing a transmission power if the mobile station does not receive the AI from the target base station.

25. The computer readable record medium as recited in claim 22, further comprising the function of d) forcing the base station controller to know a frame offset just before the base station controller (or a radio network) instructs the mobile station and the target base station to perform the handover in case that the base station controller does not know the frame offset, which is a difference between a connection frame number (CFN) of the mobile station and the a system frame number (SFN) of the target base station, thereby preventing an additional call disconnection.

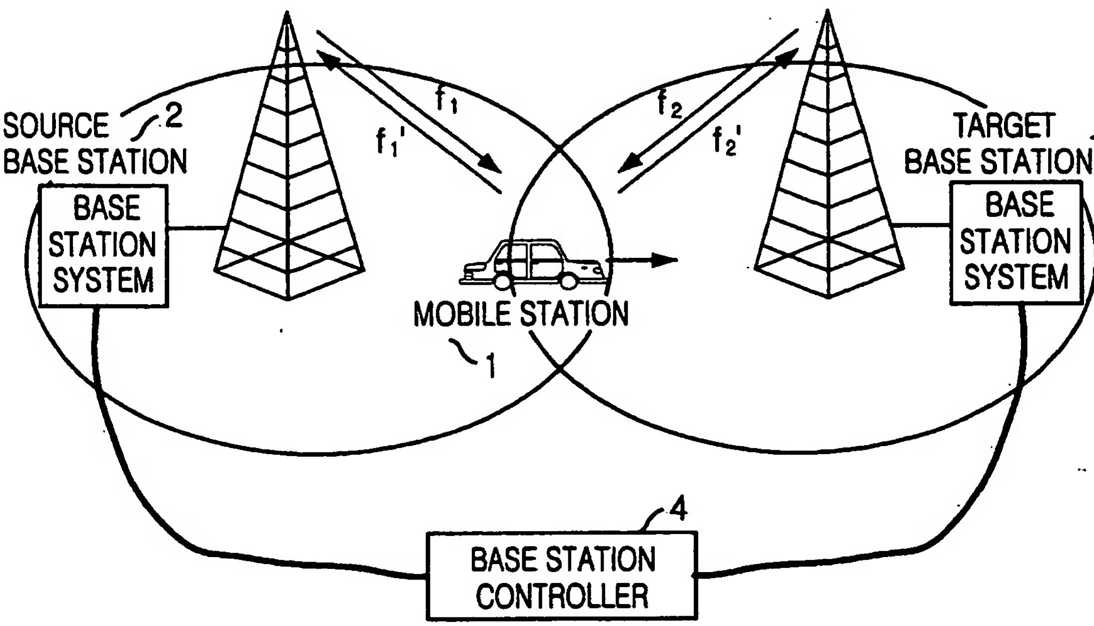
26. The computer readable record medium as recited in claim 22, further comprising the function of d) in case a base station controller knows a frame offset, the target base station, acquiring the uplink synchronization by using the preamble and reporting the acquisition of the uplink

synchronization only to the base station controller.

27. The computer readable record medium as recited in claim 22, further comprising the function of d) in case a base station controller knows a frame offset, the target base station, transmitting an AI through a new downlink of the second carrier frequency after acquiring the uplink synchronization by using the preamble and reporting the acquisition of the uplink synchronization the base station controller.

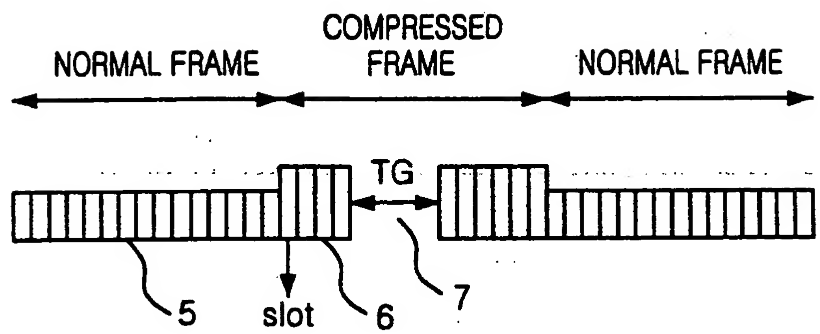
DOCID: <WO 02058280A1 I >

FIG. 1



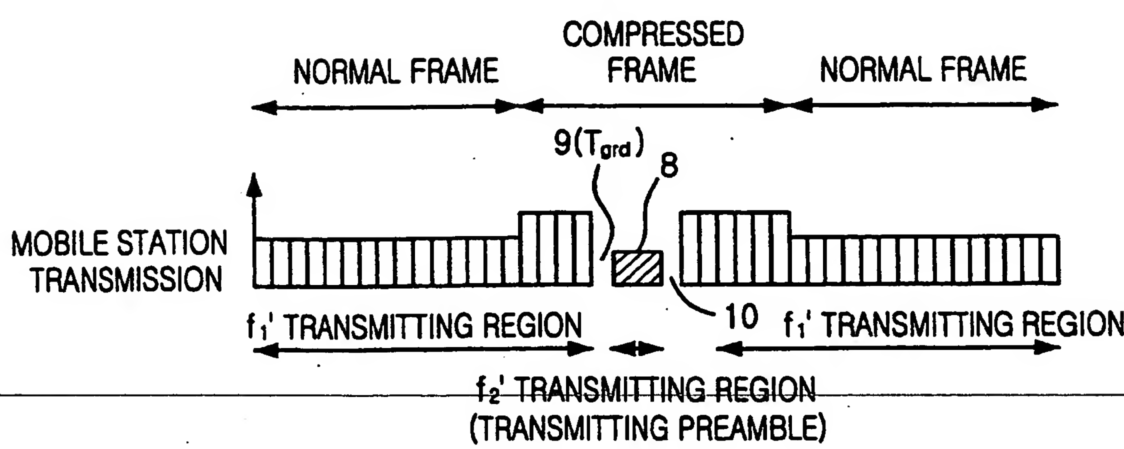
SOURCE BASE STATION
2
BASE STATION SYSTEM
f1
f1'
f2
f2'
TARGET BASE STATION
3
BASE STATION SYSTEM
MOBILE STATION
1
4
BASE STATION CONTROLLER

FIG. 2



COMPRESSED FRAME
NORMAL FRAME
NORMAL FRAME
TG
5
slot
6
7

FIG. 3



COMPRESSED FRAME
NORMAL FRAME
NORMAL FRAME
9(T_{grd})
8
MOBILE STATION TRANSMISSION
10
f_1' TRANSMITTING REGION
f_1' TRANSMITTING REGION
f_2' TRANSMITTING REGION
(TRANSMITTING PREAMBLE)

FIG. 4

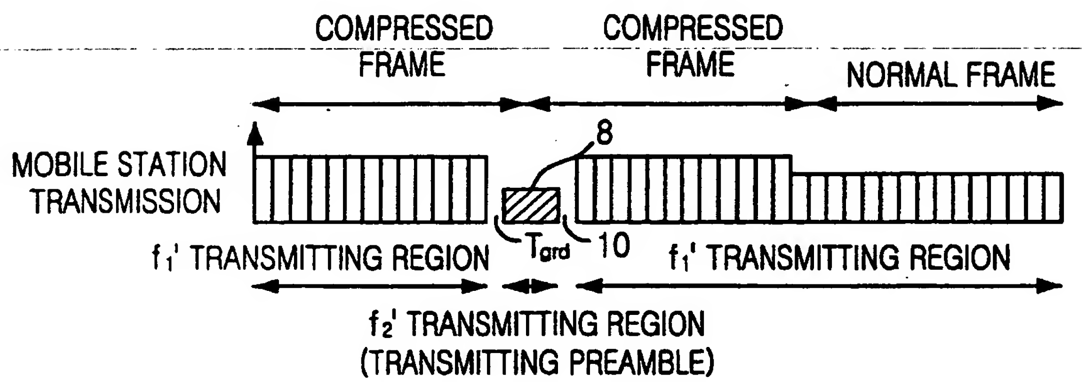

COMPRESSED FRAME
COMPRESSED FRAME
NORMAL FRAME
MOBILE STATION TRANSMISSION
8
T_{grd}
10
f_1' TRANSMITTING REGION
f_1' TRANSMITTING REGION
f_2' TRANSMITTING REGION
(TRANSMITTING PREAMBLE)

FIG. 5

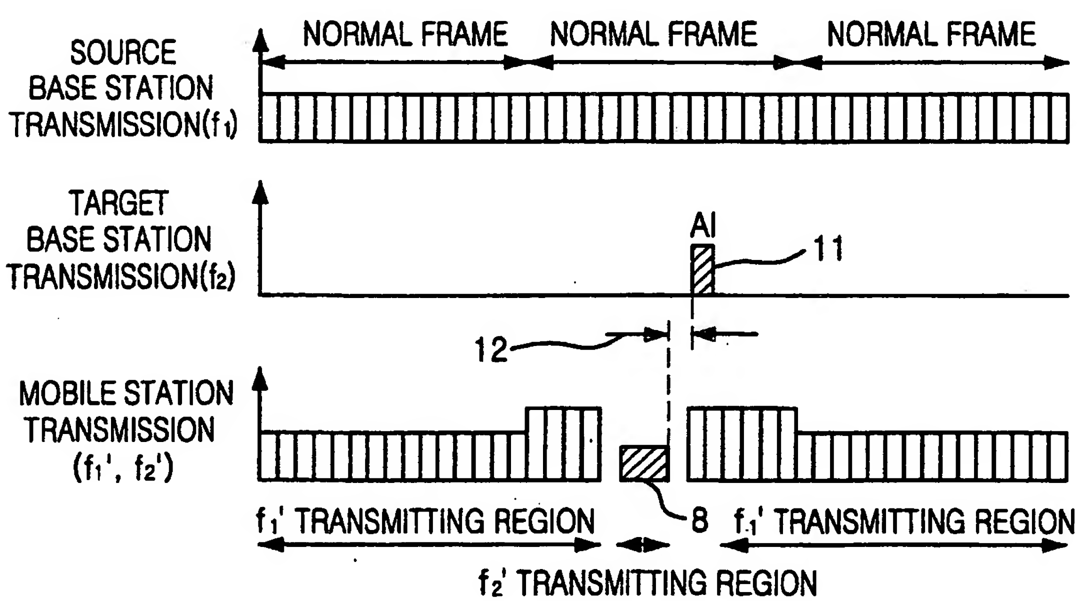

SOURCE BASE STATION TRANSMISSION(f_1)
NORMAL FRAME
NORMAL FRAME
NORMAL FRAME
TARGET BASE STATION TRANSMISSION(f_2)
AI
11
12
MOBILE STATION TRANSMISSION (f_1', f_2')
8
f_1' TRANSMITTING REGION
f_1' TRANSMITTING REGION
f_2' TRANSMITTING REGION

FIG. 6

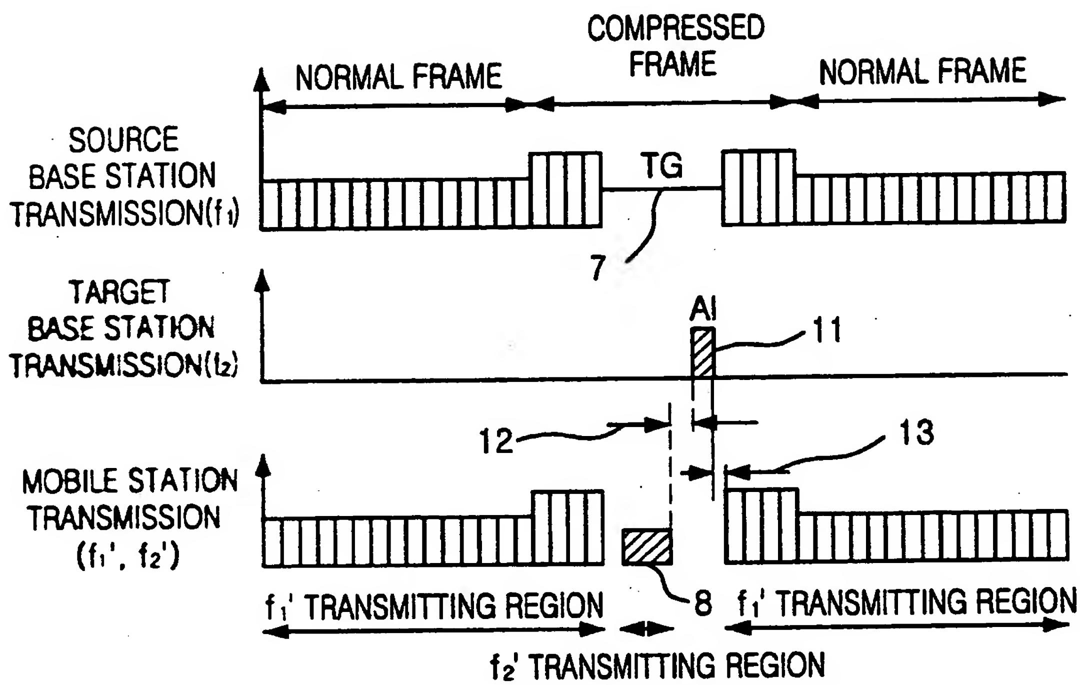

COMPRESSED FRAME
NORMAL FRAME
NORMAL FRAME
SOURCE BASE STATION TRANSMISSION(f1)
TG
7
TARGET BASE STATION TRANSMISSION(f2)
AI
11
12
13
MOBILE STATION TRANSMISSION (f1', f2')
8
f1' TRANSMITTING REGION
f1' TRANSMITTING REGION
f2' TRANSMITTING REGION

FIG. 7

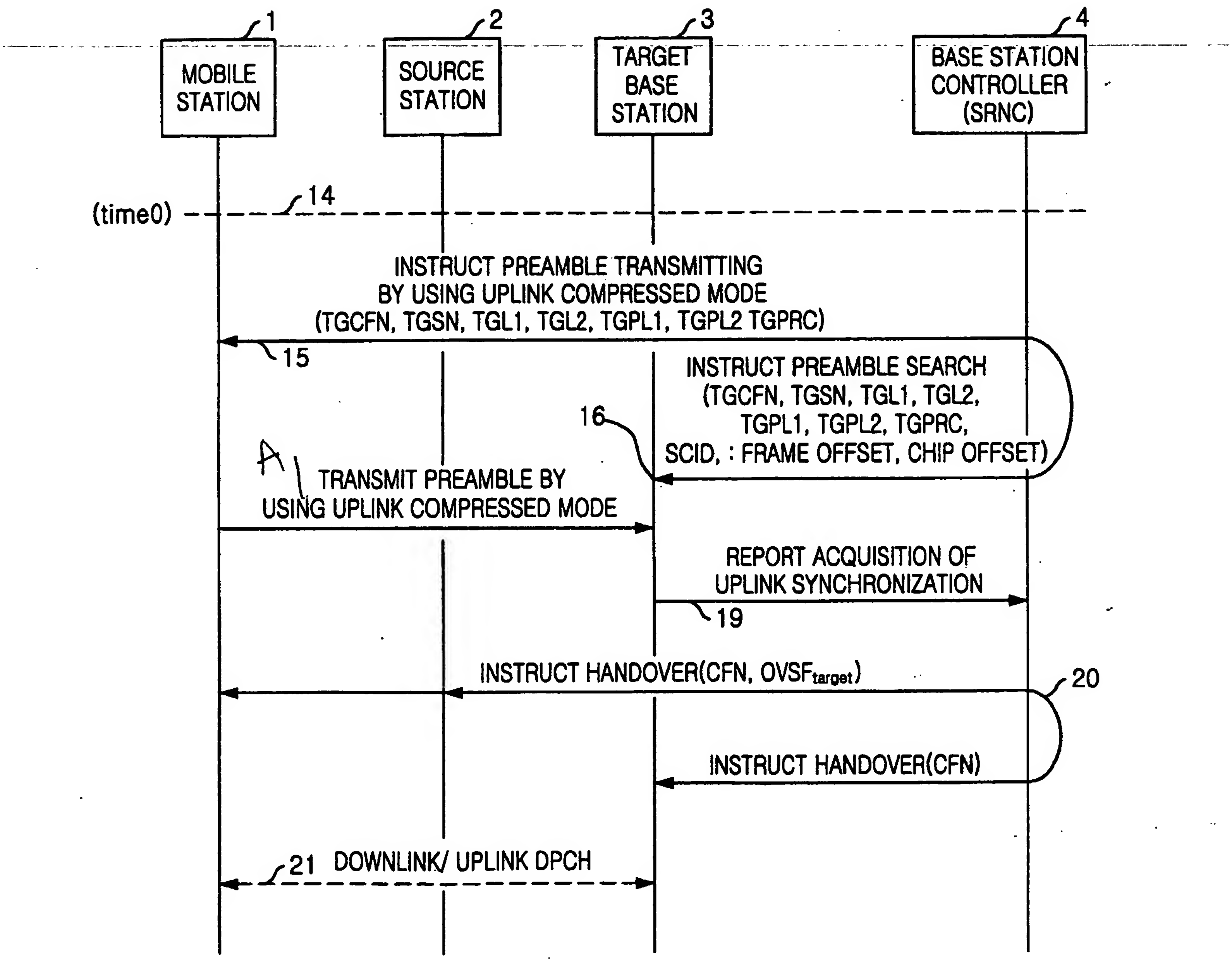
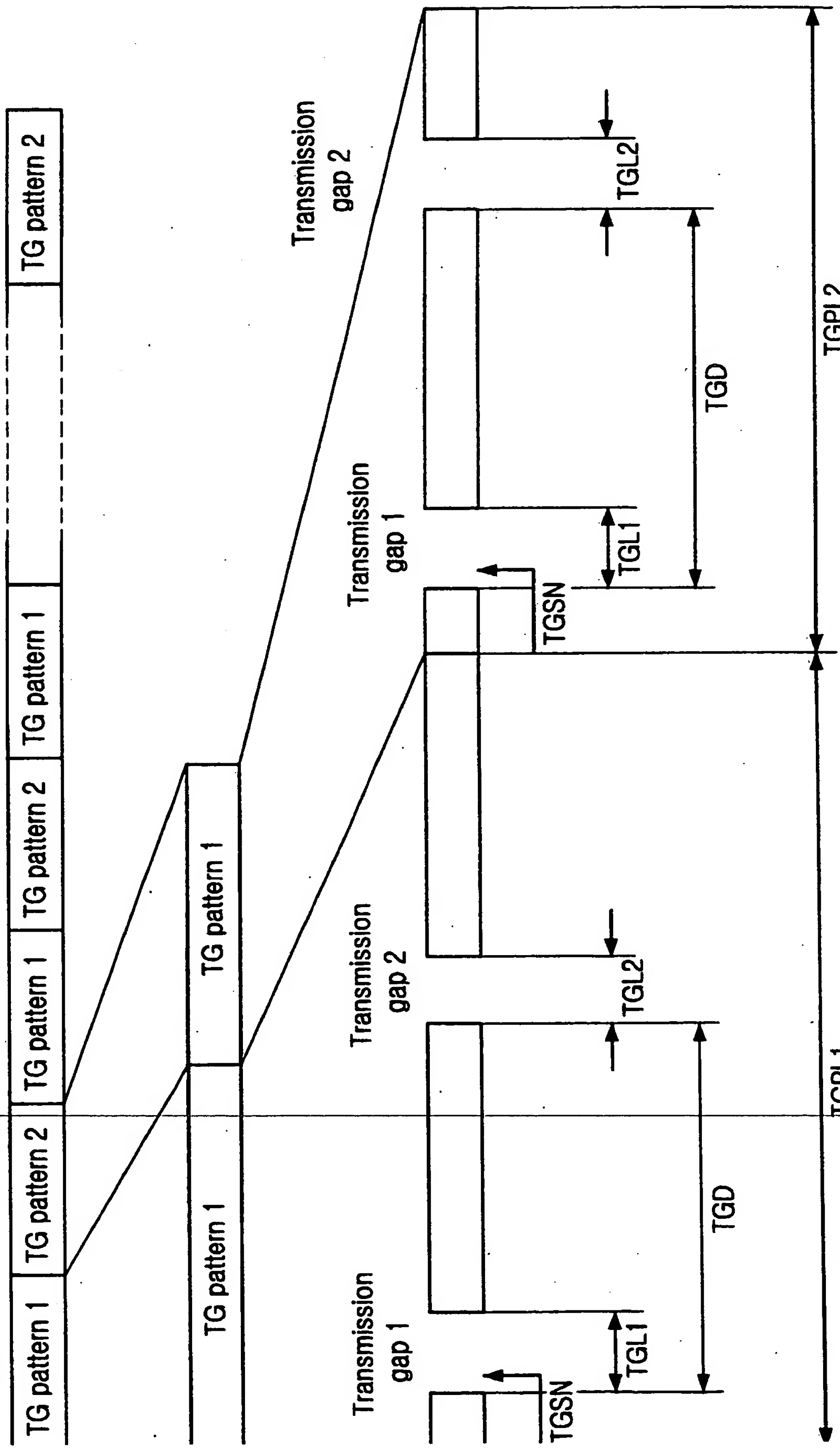

1
MOBILE STATION
2
SOURCE STATION
3
TARGET BASE STATION
4
BASE STATION CONTROLLER (SRNC)
(time0)
14
INSTRUCT PREAMBLE TRANSMITTING BY USING UPLINK COMPRESSED MODE (TGCFN, TGSN, TGL1, TGL2, TGPL1, TGPL2 TGPRC)
15
INSTRUCT PREAMBLE SEARCH (TGCFN, TGSN, TGL1, TGL2, TGPL1, TGPL2, TGPRC, SCID, : FRAME OFFSET, CHIP OFFSET)
16
A
TRANSMIT PREAMBLE BY USING UPLINK COMPRESSED MODE
REPORT ACQUISITION OF UPLINK SYNCHRONIZATION
19
INSTRUCT HANDOVER(CFN, OVSFtarget)
20
INSTRUCT HANDOVER(CFN)
21
DOWNLINK/ UPLINK DPCH

FIG. 8


#1
#2
#3
#4
#5
#TGPRC
TG pattern 1
TG pattern 2
TG pattern 1
TG pattern 2
TG pattern 1
TG pattern 2
TG pattern 1
TG pattern 1
Transmission gap 1
Transmission gap 2
Transmission gap 1
Transmission gap 2
TGSN
TGL1
TGL2
TGD
TGPL1
TGSN
TGL1
TGL2
TGD
TGPL2

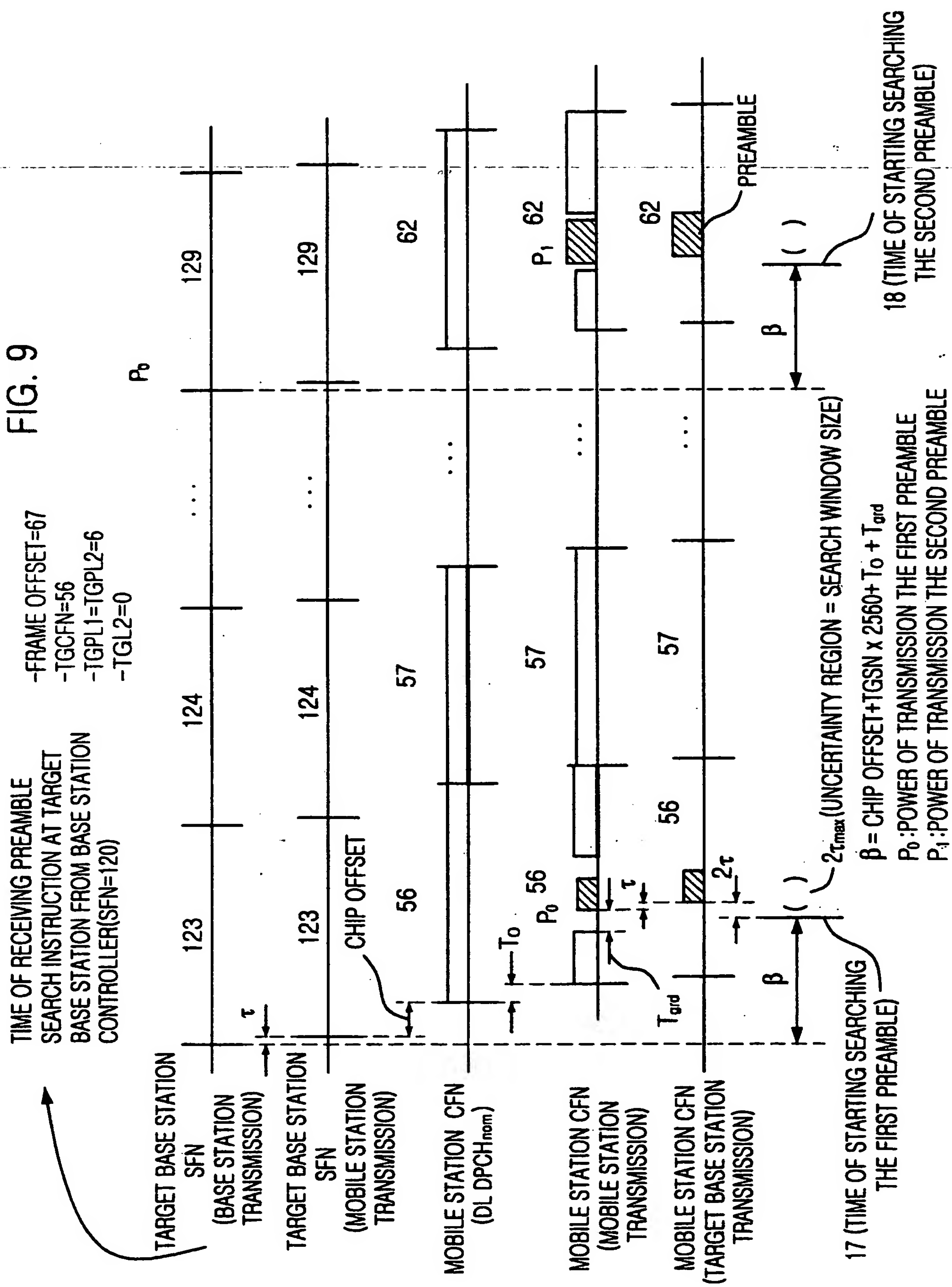

TIME OF RECEIVING PREAMBLE SEARCH INSTRUCTION AT TARGET BASE STATION FROM BASE STATION CONTROLLER(SFN=120)
-FRAME OFFSET=67
-TGCFN=56
-TGPL1=TGPL2=6
-TGL2=0
P_0
TARGET BASE STATION SFN (BASE STATION TRANSMISSION)
TARGET BASE STATION SFN (MOBILE STATION TRANSMISSION)
MOBILE STATION CFN (DL DPCH$_{nom}$)
MOBILE STATION CFN (MOBILE STATION TRANSMISSION)
MOBILE STATION CFN (TARGET BASE STATION TRANSMISSION)
123
124
129
56
57
62
τ
CHIP OFFSET
T_O
T_{grd}
P_0
P_1
2τ
PREAMBLE
β
17 (TIME OF STARTING SEARCHING THE FIRST PREAMBLE)
18 (TIME OF STARTING SEARCHING THE SECOND PREAMBLE)
$2\tau_{max}$ (UNCERTAINTY REGION = SEARCH WINDOW SIZE)
β = CHIP OFFSET+TGSN x 2560+ T_O + T_{grd}
P_0 :POWER OF TRANSMISSION THE FIRST PREAMBLE
P_1 :POWER OF TRANSMISSION THE SECOND PREAMBLE

FIG. 9

FIG. 10

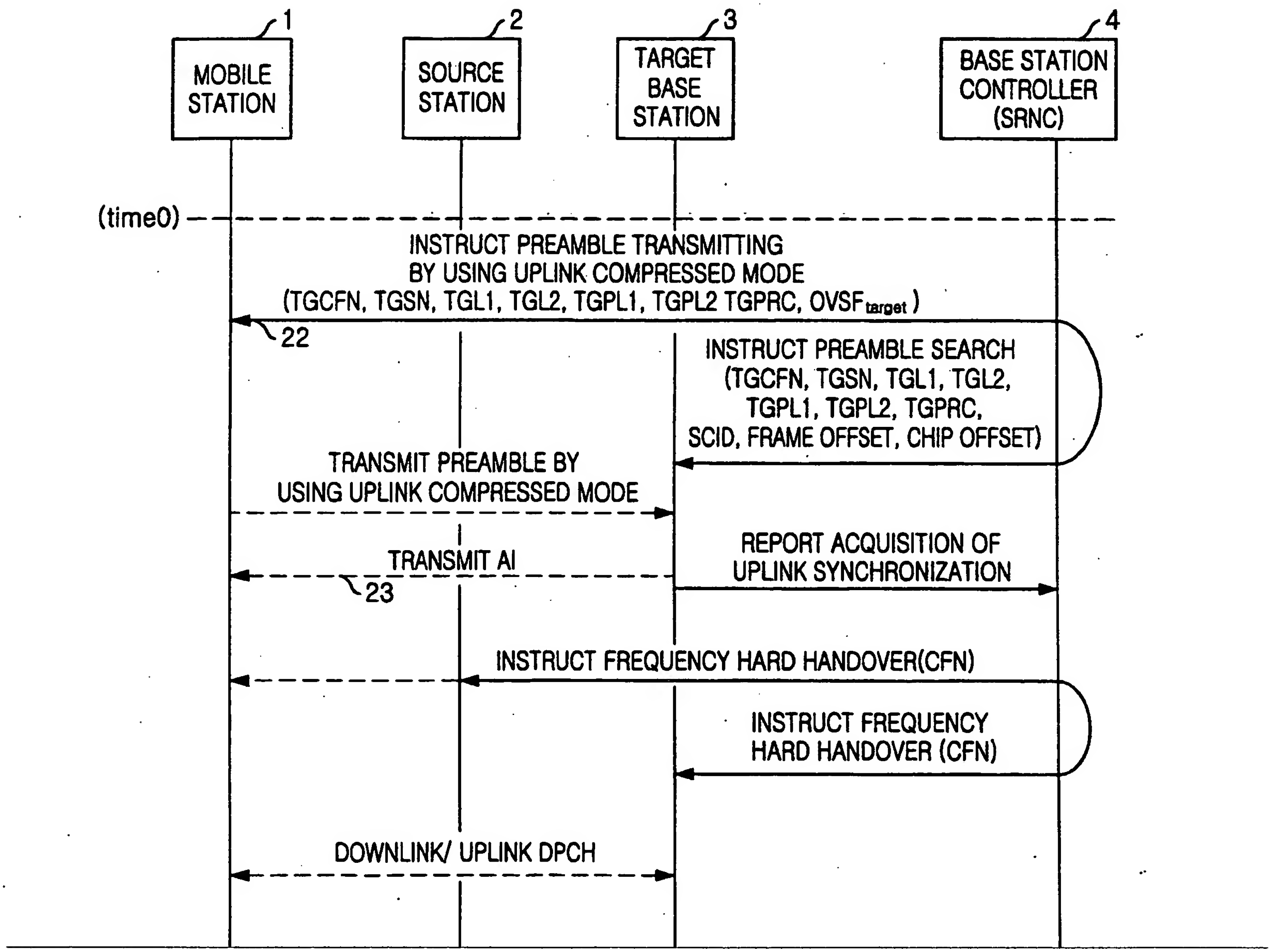

1
MOBILE STATION
2
SOURCE STATION
3
TARGET BASE STATION
4
BASE STATION CONTROLLER (SRNC)
(time0)
INSTRUCT PREAMBLE TRANSMITTING BY USING UPLINK COMPRESSED MODE (TGCFN, TGSN, TGL1, TGL2, TGPL1, TGPL2 TGPRC, OVSF target)
22
INSTRUCT PREAMBLE SEARCH (TGCFN, TGSN, TGL1, TGL2, TGPL1, TGPL2, TGPRC, SCID, FRAME OFFSET, CHIP OFFSET)
TRANSMIT PREAMBLE BY USING UPLINK COMPRESSED MODE
TRANSMIT AI
23
REPORT ACQUISITION OF UPLINK SYNCHRONIZATION
INSTRUCT FREQUENCY HARD HANDOVER(CFN)
INSTRUCT FREQUENCY HARD HANDOVER (CFN)
DOWNLINK/ UPLINK DPCH

FIG. 11

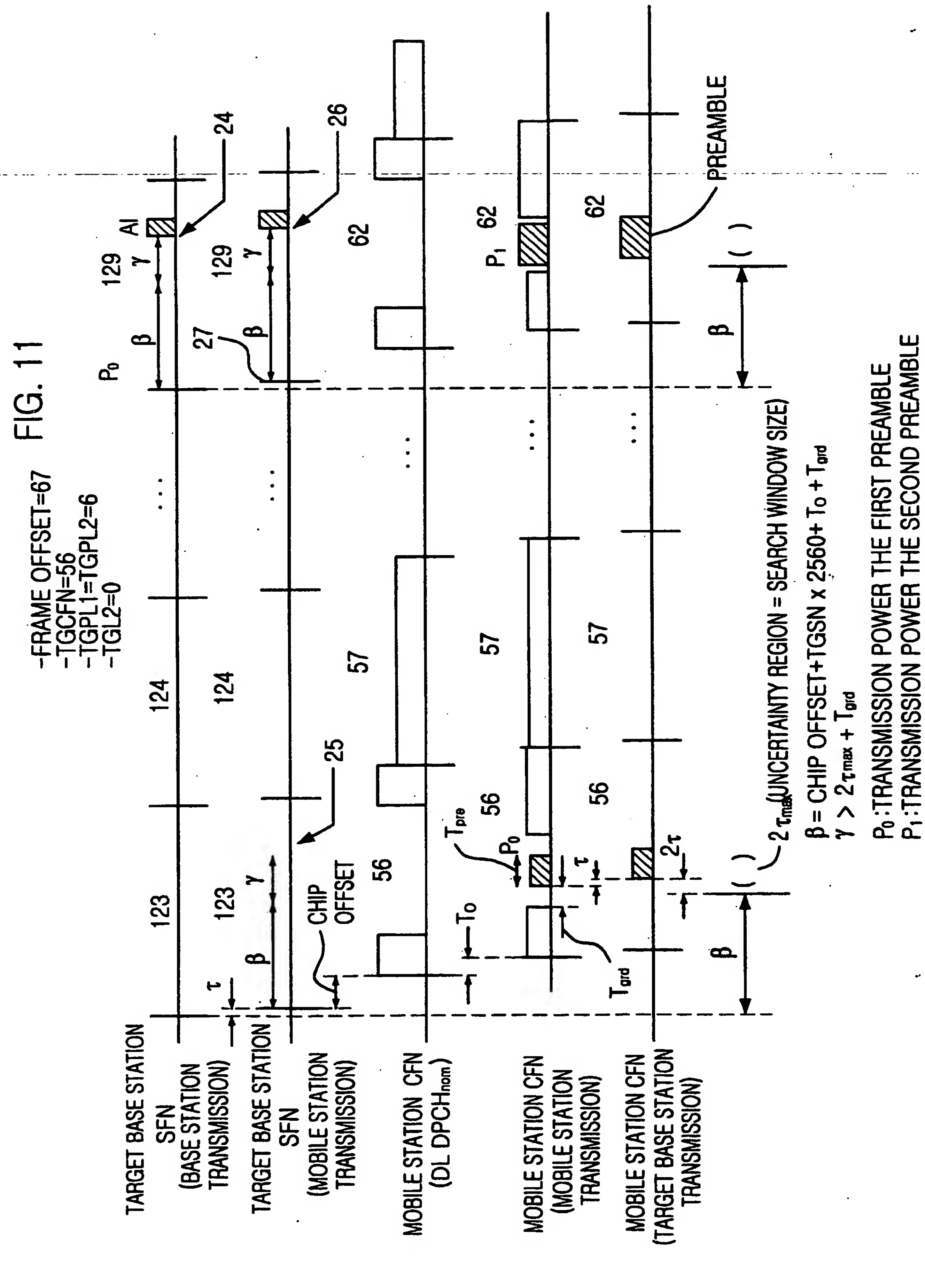

-FRAME OFFSET=67
-TGCFN=56
-TGPL1=TGPL2=6
-TGL2=0
TARGET BASE STATION SFN (BASE STATION TRANSMISSION)
TARGET BASE STATION SFN (MOBILE STATION TRANSMISSION)
MOBILE STATION CFN (DL DPCH$_{nom}$)
MOBILE STATION CFN (MOBILE STATION TRANSMISSION)
MOBILE STATION CFN (TARGET BASE STATION TRANSMISSION)
123
124
129
56
57
62
24
25
26
27
AI
PREAMBLE
CHIP OFFSET
P_0
P_1
T_{pre}
T_o
T_{grd}
τ
2τ
β
γ
$2\tau_{max}$ (UNCERTAINTY REGION = SEARCH WINDOW SIZE)
β = CHIP OFFSET+TGSN x 2560+ T_o + T_{grd}
$\gamma > 2\tau_{max} + T_{grd}$
P_0:TRANSMISSION POWER THE FIRST PREAMBLE
P_1:TRANSMISSION POWER THE SECOND PREAMBLE

FIG. 12

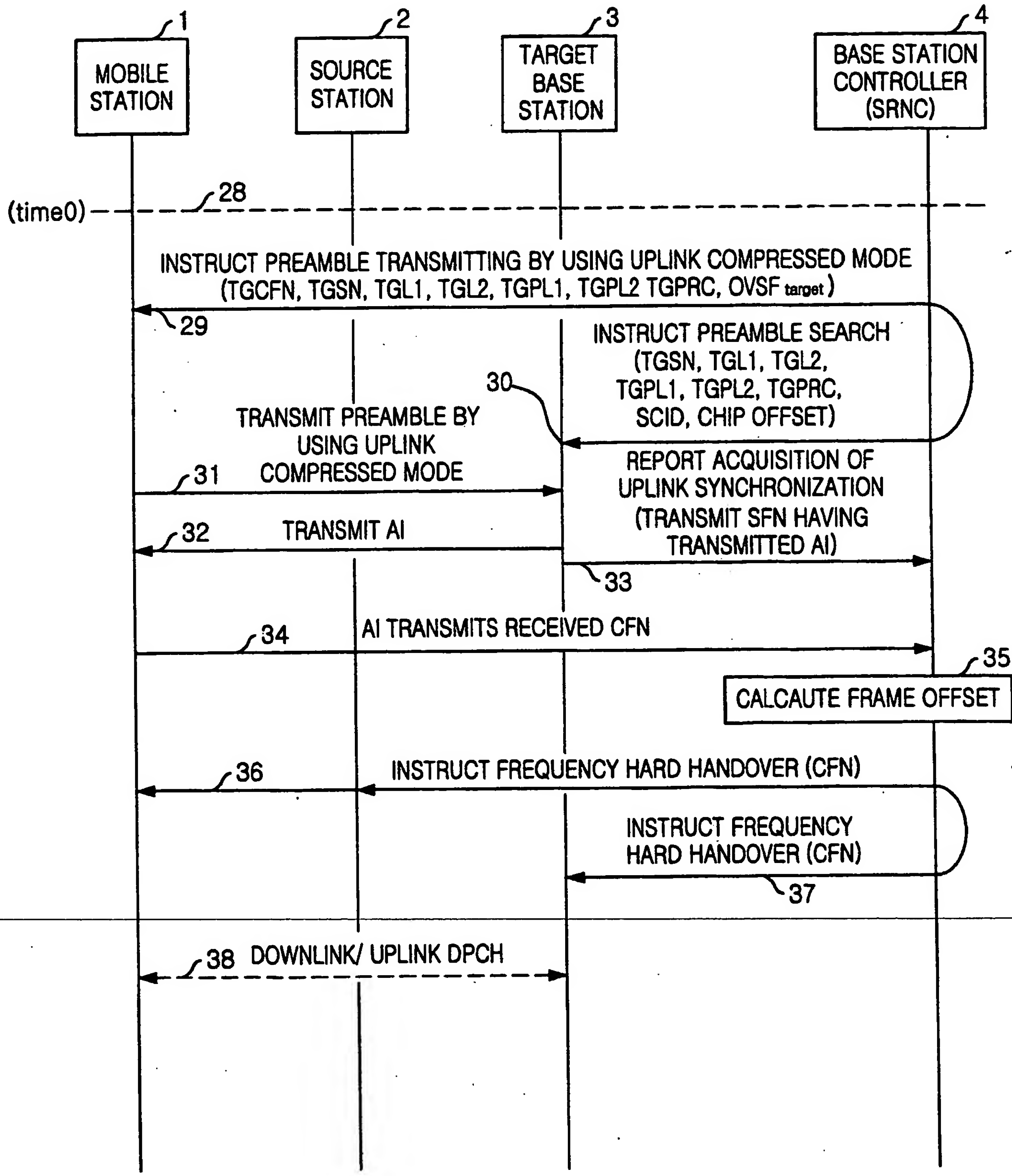

1
MOBILE STATION
2
SOURCE STATION
3
TARGET BASE STATION
4
BASE STATION CONTROLLER (SRNC)
(time0)
28
INSTRUCT PREAMBLE TRANSMITTING BY USING UPLINK COMPRESSED MODE (TGCFN, TGSN, TGL1, TGL2, TGPL1, TGPL2 TGPRC, OVSF target)
29
INSTRUCT PREAMBLE SEARCH (TGSN, TGL1, TGL2, TGPL1, TGPL2, TGPRC, SCID, CHIP OFFSET)
30
TRANSMIT PREAMBLE BY USING UPLINK COMPRESSED MODE
31
REPORT ACQUISITION OF UPLINK SYNCHRONIZATION (TRANSMIT SFN HAVING TRANSMITTED AI)
32
TRANSMIT AI
33
34
AI TRANSMITS RECEIVED CFN
35
CALCAUTE FRAME OFFSET
36
INSTRUCT FREQUENCY HARD HANDOVER (CFN)
INSTRUCT FREQUENCY HARD HANDOVER (CFN)
37
38
DOWNLINK/ UPLINK DPCH

FIG. 13

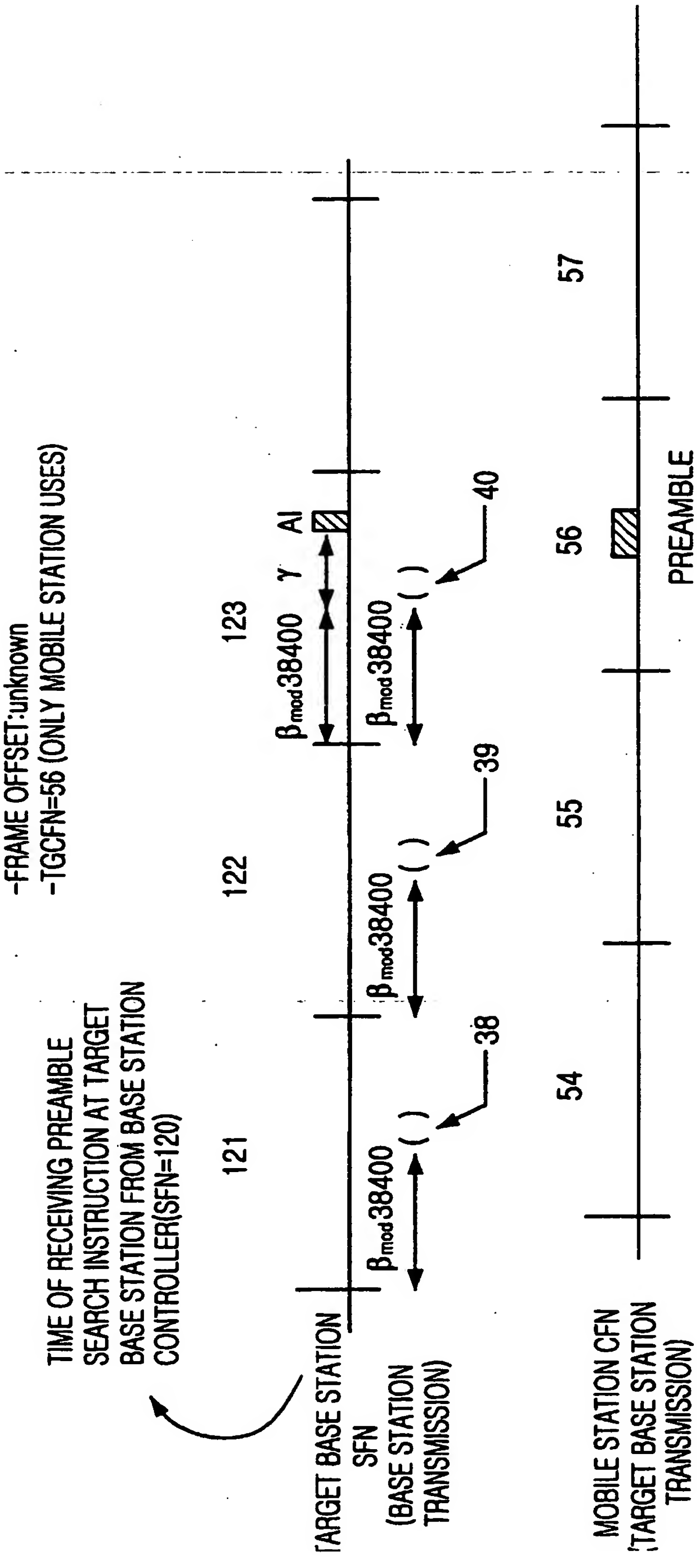

-FRAME OFFSET:unknown
-TGCFN=56 (ONLY MOBILE STATION USES)
TIME OF RECEIVING PREAMBLE SEARCH INSTRUCTION AT TARGET BASE STATION FROM BASE STATION CONTROLLER(SFN=120)
TARGET BASE STATION SFN (BASE STATION TRANSMISSION)
121
122
123
$\beta_{mod}38400$
γ
AI
38
39
40
( )
MOBILE STATION CFN (TARGET BASE STATION TRANSMISSION)
54
55
56
57
PREAMBLE

FIG. 14

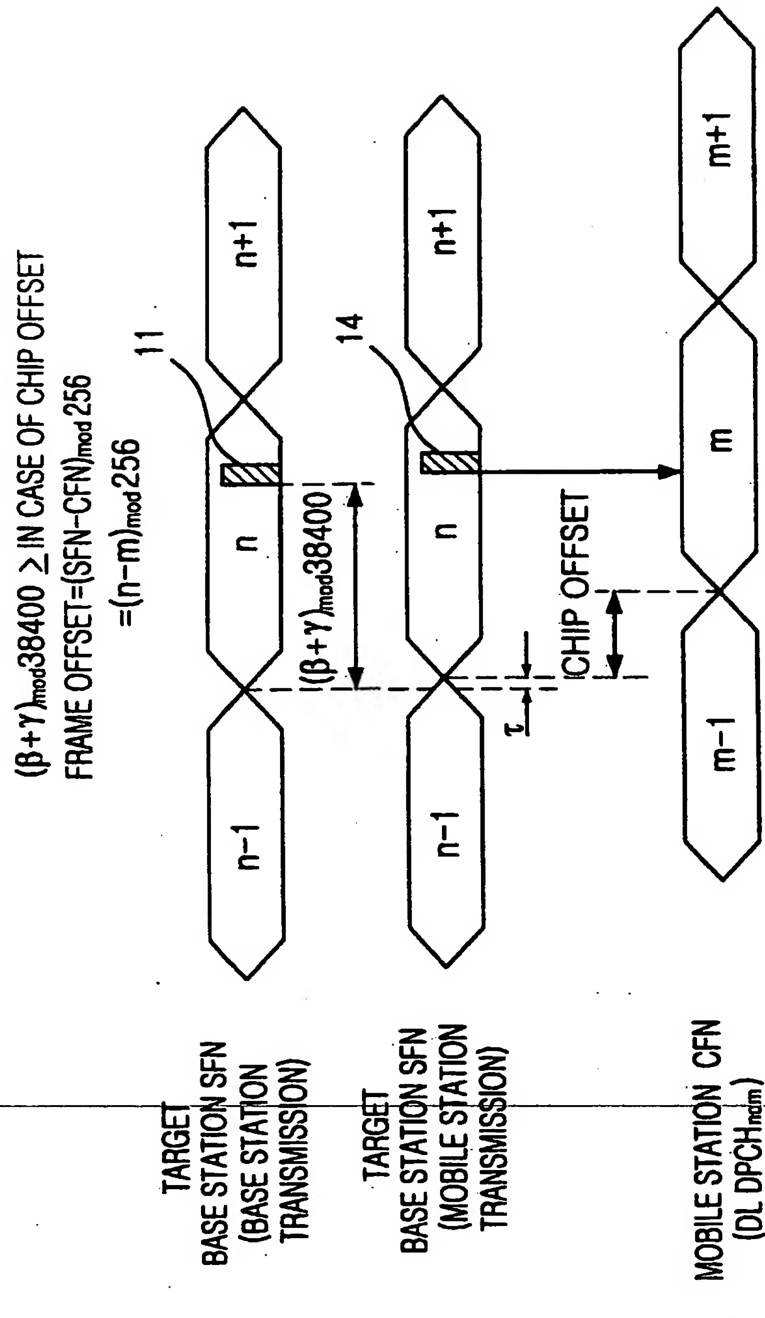

$(\beta+\gamma)_{mod}38400 \geq$ IN CASE OF CHIP OFFSET
FRAME OFFSET=$(SFN-CFN)_{mod}256$
$=(n-m)_{mod}256$
11
14
n-1
n
n+1
m-1
m
m+1
$(\beta+\gamma)_{mod}38400$
τ
CHIP OFFSET
TARGET BASE STATION SFN (BASE STATION TRANSMISSION)
TARGET BASE STATION SFN (MOBILE STATION TRANSMISSION)
MOBILE STATION CFN (DL $DPCH_{nom}$)

FIG. 15

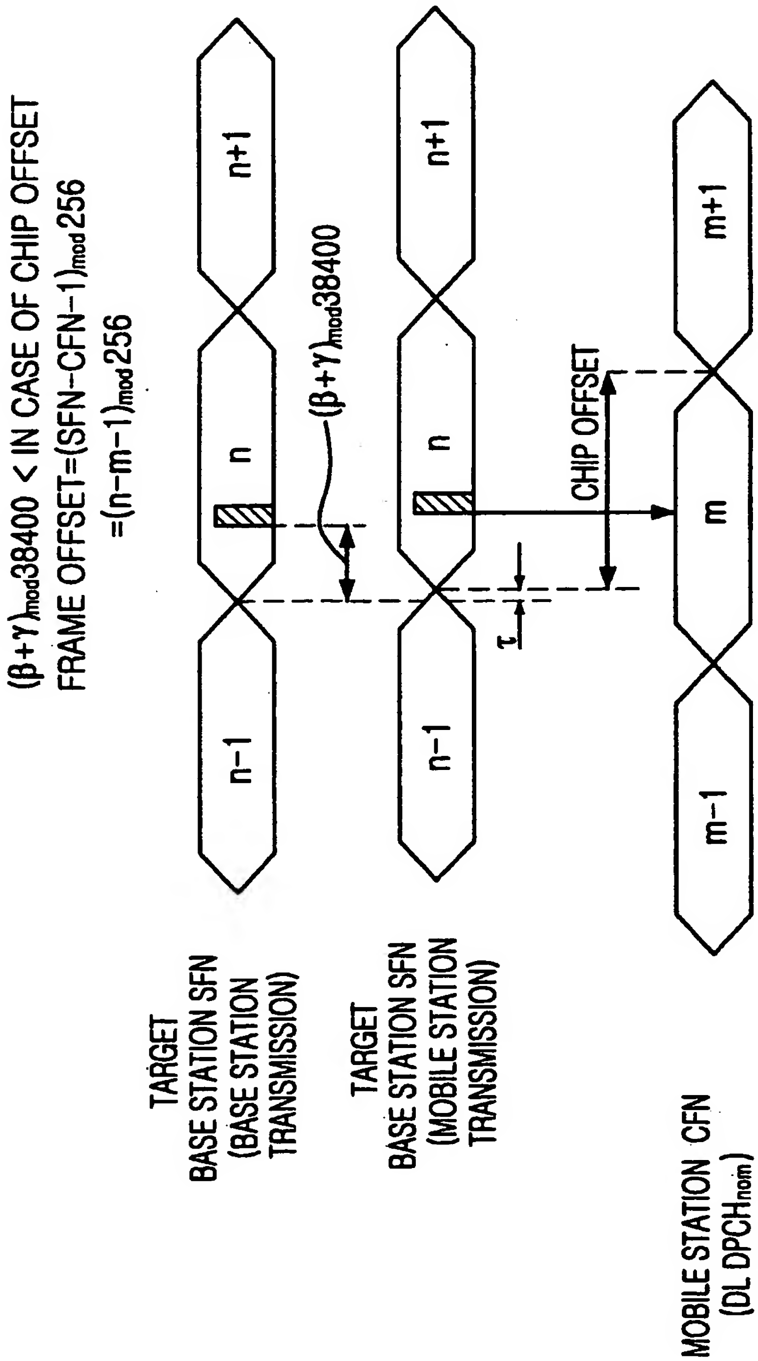

$(\beta+\gamma)_{mod}38400$ < IN CASE OF CHIP OFFSET
FRAME OFFSET=$(SFN-CFN-1)_{mod}256$
$=(n-m-1)_{mod}256$
TARGET BASE STATION SFN (BASE STATION TRANSMISSION)
TARGET BASE STATION SFN (MOBILE STATION TRANSMISSION)
MOBILE STATION CFN ($DL\ DPCH_{nom}$)
n-1
n
n+1
m-1
m
m+1
$(\beta+\gamma)_{mod}38400$
CHIP OFFSET
τ

FIG. 16

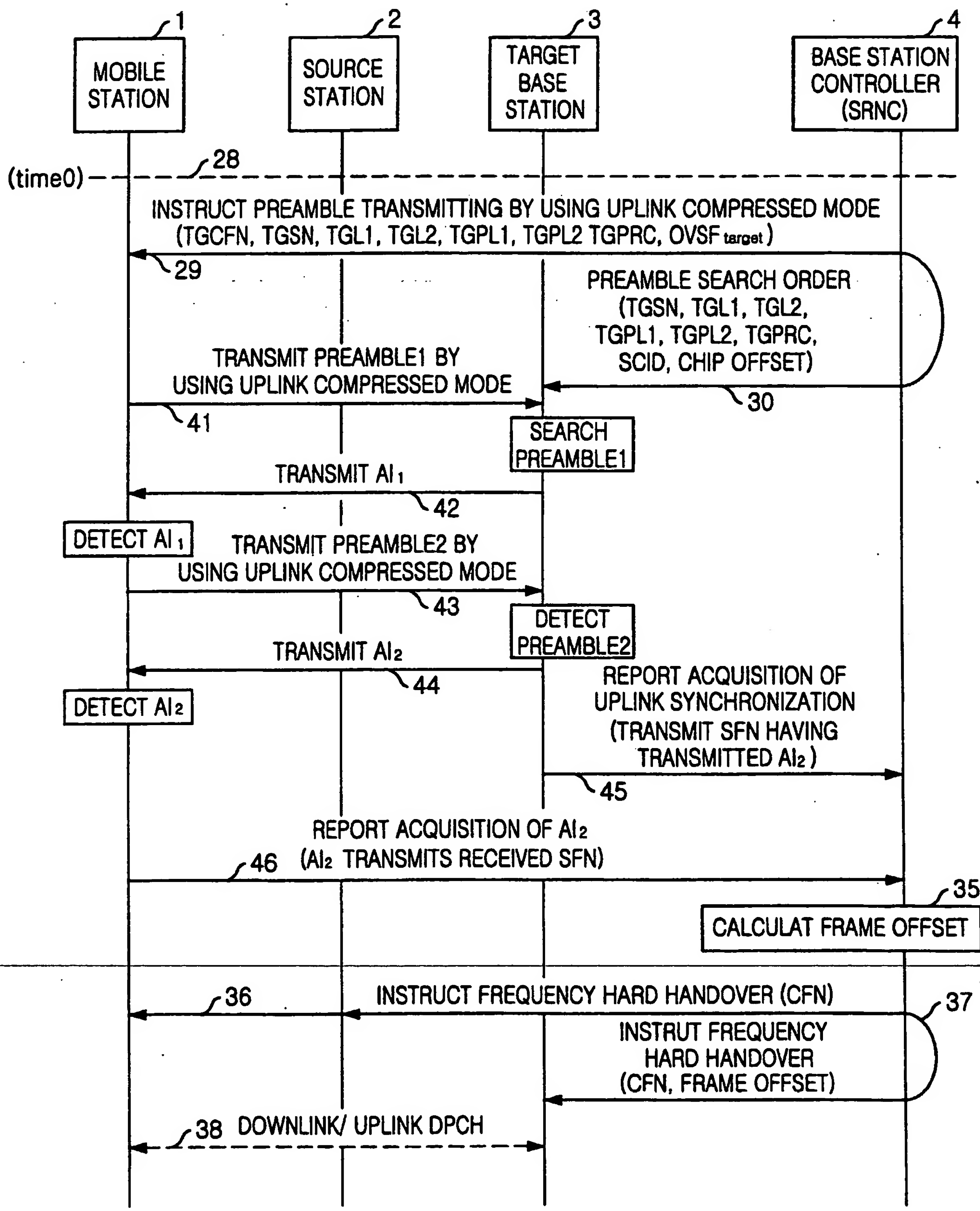

1
MOBILE STATION
2
SOURCE STATION
3
TARGET BASE STATION
4
BASE STATION CONTROLLER (SRNC)
(time0)
28
INSTRUCT PREAMBLE TRANSMITTING BY USING UPLINK COMPRESSED MODE (TGCFN, TGSN, TGL1, TGL2, TGPL1, TGPL2 TGPRC, OVSF target)
29
PREAMBLE SEARCH ORDER (TGSN, TGL1, TGL2, TGPL1, TGPL2, TGPRC, SCID, CHIP OFFSET)
30
TRANSMIT PREAMBLE1 BY USING UPLINK COMPRESSED MODE
41
SEARCH PREAMBLE1
TRANSMIT AI1
42
DETECT AI1
TRANSMIT PREAMBLE2 BY USING UPLINK COMPRESSED MODE
43
DETECT PREAMBLE2
TRANSMIT AI2
44
DETECT AI2
REPORT ACQUISITION OF UPLINK SYNCHRONIZATION (TRANSMIT SFN HAVING TRANSMITTED AI2)
45
REPORT ACQUISITION OF AI2 (AI2 TRANSMITS RECEIVED SFN)
46
35
CALCULAT FRAME OFFSET
36
INSTRUCT FREQUENCY HARD HANDOVER (CFN)
37
INSTRUT FREQUENCY HARD HANDOVER (CFN, FRAME OFFSET)
38
DOWNLINK/ UPLINK DPCH

FIG. 17

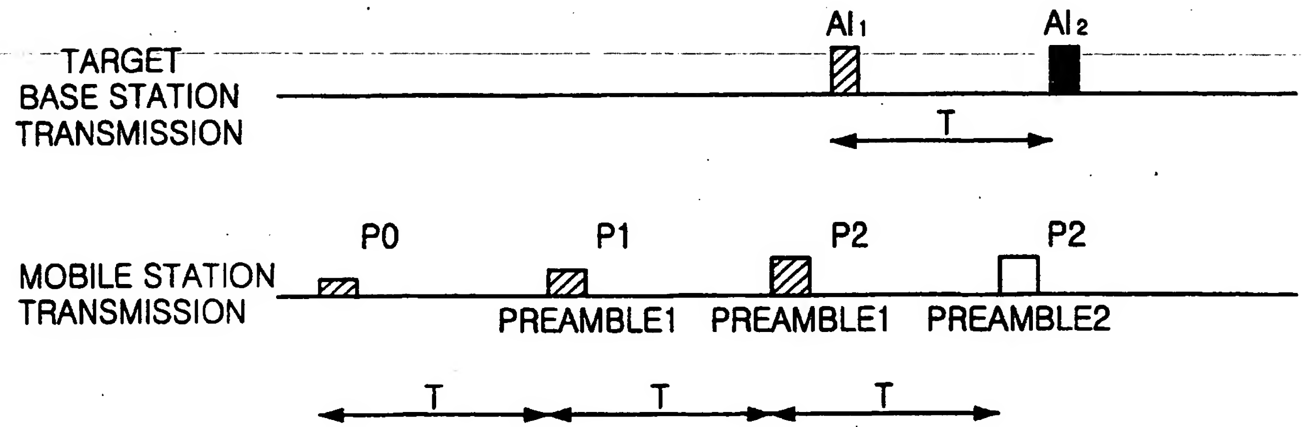
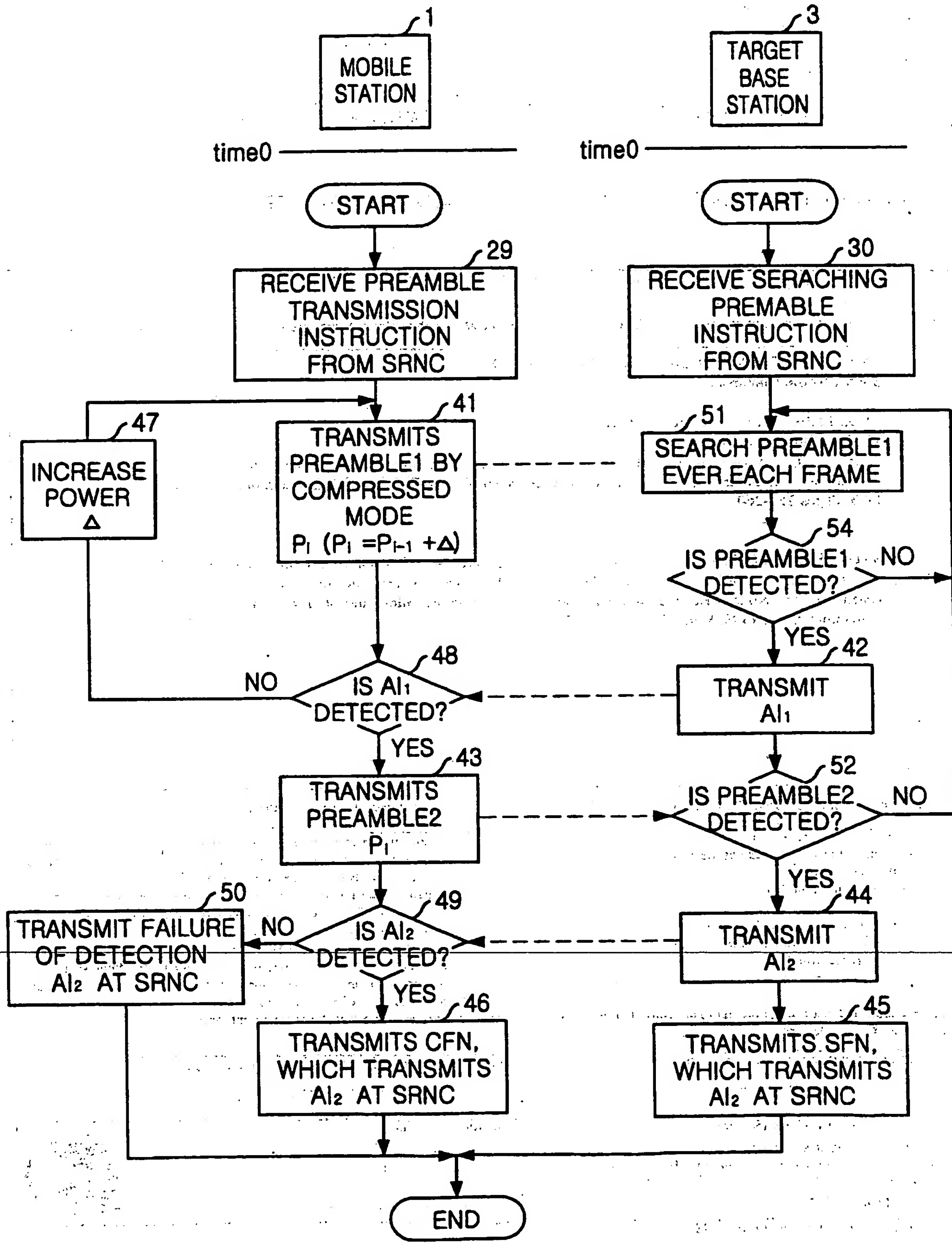

AI1
AI2
TARGET
BASE STATION
TRANSMISSION
T
P0
P1
P2
P2
MOBILE STATION
TRANSMISSION
PREAMBLE1
PREAMBLE1
PREAMBLE2
T
T
T

FIG. 18



1
MOBILE STATION
3
TARGET BASE STATION
time0
time0
START
START
29
RECEIVE PREAMBLE TRANSMISSION INSTRUCTION FROM SRNC
30
RECEIVE SERACHING PREMABLE INSTRUCTION FROM SRNC
47
INCREASE POWER Δ
41
TRANSMITS PREAMBLE1 BY COMPRESSED MODE P_i ($P_i = P_{i-1} + \Delta$)
51
SEARCH PREAMBLE1 EVER EACH FRAME
54
IS PREAMBLE1 DETECTED?
NO
YES
42
TRANSMIT AI_1
48
IS AI_1 DETECTED?
NO
YES
43
TRANSMITS PREAMBLE2 P_i
52
IS PREAMBLE2 DETECTED?
NO
YES
44
TRANSMIT AI_2
50
TRANSMIT FAILURE OF DETECTION AI_2 AT SRNC
49
IS AI_2 DETECTED?
NO
YES
46
TRANSMITS CFN, WHICH TRANSMITS AI_2 AT SRNC
45
TRANSMITS SFN, WHICH TRANSMITS AI_2 AT SRNC
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/02314

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H04B 7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC H04B7/26, H04Q7/22, H04B17/00, H04B1/00, H04B7/204, H04B7/212

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,729,826(Charles D. Gavrilovich) 17 MARCH 1998 See the whole Document	1-21
A	US 6,212,368 B1(Ericsson Inc) 03 April 2001 See the whole Document	1-21
A	BAIER, A; PANZER, H 'Multi-rate DS-CDMA radio interface for third-generation cellular systems" In: The Seventh IEE European Coference on Mobile and Personal Communications, 1993. Pages:255-260	1-21
A	NAGATSUKA, M; ISHIGAWA, Y; HAGIWARA, J; ONOE, S(NTT Mobile Commun. Network Inc, Japan) 'CDMA packet transmission control in the third generation mobile communications system' In: The Ninth IEEE International Sysposium on Personal, Indoor and Mobile Radio Communications, 1998, Vol.1, Pages 178-182	1-21

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevence

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 APRIL 2002 (25.04.2002)	27 APRIL 2002 (27.04.2002)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 920 Dunsan-dong, Seo-gu, Daejeon Metropolitan City 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

SEO, Jin Won

Telephone No. 82-42-481-5706

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/02314

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HAMABE, K; YOSHIDA, S; USHIROKAWA, A(C&C Syst, Res. Labs., NEC Corp., Kawasaki, Japan) 'Fprward-link power control utilizing neighboring-cell pilot power for DS-CDMA cellular systems', IEEE 47th Vehicular Technology Conference, 1997, on Vol.2, pages 939-942.	1-21

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